BOSTON SCHOOL SERIES

THE INFORMATION READER No. 3.

MAN AND MATERIALS

BOSTON SCHOOL SUPPLY CO.

Boston School Series

THE

INFORMATION READERS

NUMBER 3

MAN AND MATERIALS

BY

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PREFACE.

To-day's school curriculum includes only one subject, Reading, in which the text-books have not kept pace with educational progress. There is no substantial difference between the old American Readers, published sixty years ago, and any series now in use. Yet this fact should not cause surprise. One reading-book must resemble another, if both are merely compilations of extracts chosen for elocutionary purposes. Our present readers are, it is true, more sumptuous specimens of book-making, but children are not sent to school to admire book-covers or to look at pictures.

No selections from Shakspeare and Milton have been culled for the Information Series. The books contain no "pieces to speak." Excerpts on Constitutional Government, the Destiny of Man and other trivial subjects, must be looked for elsewhere. Nor is the text of the Infor-

mation Readers a tissue of pretty stories. Means to waste the precious hours of school life can readily be invented, if such waste be desired. No effort has been spared to render information attractive, indeed; but the fundamental aim of the series has not been ignored in a single lesson.

In these books elocution is subordinated to instruction, — such instruction as will aid the young learner to understand the life of the world around him. How many school graduates of this year can describe the sources from which food is obtained or can tell how it is marketed? How many appreciate the importance of the railroad as a factor in determining the cost of living in town or country? How many have any knowledge of the processes employed in making cloth? How many know how gas is manufactured? or how steel is produced? or how newspapers are printed?

To the educational public the editors of this series have endeavored to present reading-books the perusal of which will stimulate the perceptive faculties of the pupil, store his mind with practical information, and interest him in various arts and occupations by which hundreds of millions of persons earn their daily bread. Above

all, it is hoped that the books will create and foster in the mind of every young reader a just appreciation of the nobility of manual labor.

In the preparation of these volumes several distinguished educators have shown the most friendly interest. The invaluable aid of their counsel and encouragement is gratefully acknowledged.

E. A. B.
H. W. C.
W. G. P.
R. L.

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MAN AND MATERIALS.

Lesson I.

In a Coal-Mine.

If you would visit the domains of King Coal you had better first slip on an old coat, and hide your hair under an old cap; for we shall most likely get very dingy ere we return from the underground journey we propose to take. This journey is down — down — down into one of the coal-mines so numerous in Pennsylvania; a State which is rich in iron ore also, and in limestone that helps to purify it, when they are melted together in any of those tall blast-furnaces which cluster near the coal-pits' brows.

The huge, circular mouth of a pit-shaft is not at all tempting to a looker-on. Yet here we are, and down we must go; so take your safety-lamp, step onto the "cage," grasp that iron bar, and bid good-by to daylight. A bell gives a signal, a stationary engine unwinds the steel ropes that hold our cage firmly enough, no doubt, though we are

is swinging above our heads, and off for the upper earth, where, to tell the truth, it is possible you wish yourself safely landed again ; for of all weird, dismal places the worst one is a mine.

Yet cheer up, fellow-traveler ! Your eyes will soon get accustomed to peer through the darkness, and your ears to distinguish the various noises and far-away rumblings that fill the place with its strangely mysterious terrors. Yonder we see a great coming and going of shadowy men, of clattering laden corves, or tubs, and of trotting mules. We hear shouting resounding through echoing galleries, which appear to branch off from a main one, and vanish into blackness in every direction.

Altogether it is at first quite bewildering, yet in a very little time the darkness seems to clear away somewhat, so that we scarcely need peer at our lamps so anxiously before preparing to follow a sable young sojourner in these underground regions. He marches us to the principal roadway, along which stretches a line of car-rails, the use of which we presently discover.

For some time our onward progress is easy enough ; we are getting used to the close atmosphere, and the tiny twinkling lights begin to look quite natural. Presently we have to stoop while walking, in order to avoid rough knocks upon our heads ; next we are alarmed by a most peculiar

noise in advance of us — it sounds like distant thunder. We peer anxiously into the darkness, but can make out nothing. The noise is rapidly coming straight in our direction, and is increasing to a most fearful din.

What dreadful danger is going to befall us? At last we cannot forbear shrieking out an inquiry to our guide, who shrieks back that it is only a train of heavily laden corves that go up and down this track.

"A return one passes them just here. Better step back out of their road: there is not room for them and for us at the same time. Get back quickly, or" — the rumbling hollow sound drowns the rest of his remark, and we look about us frantically anxious, for the noise is deafening and the danger uncertain.

However, we retreat close to the rough wall, and we find, much to our relief, that cut into it, no doubt to provide for such a dilemma as ours, are niches into one of which any person may crowd himself. We wait, and a heavily laden train of corves, — each corve holds about 1,200 pounds of coal, — passes us on the way to the mouth of the shaft.

After a convoy of empties clatters by in the opposite direction, we step out and resume our voyage of discovery, leaving what may be termed

the highroad of the mine to venture into all sorts of dark holes and corners, that we may get a better idea of what those poor fellows have to endure who toil in heat and darkness for the black treas-

Miners at Work.

ure which is to carry warmth and light and comfort to the busy world above.

We are told that in some parts of the mine these strong "hewers" — the actual diggers, I mean — can loosen as much as six tons of coal a day from the firm bed in which it has lain undis-

turbed for so many ages; but progress is much more slow in what is known as "low traveling," where the vein of coal is very narrow — sometimes not much more than two feet thick; then the poor collier has a hard task to accomplish.

The only possible manner by which, pick in hand, he can work his way into the vein is by lying face downwards. Stretched full-length upon a kind of low iron cart, he propels this forward with his bare toes, painfully hammering and picking his way as he moves thus uncomfortably, creeping snail-like into apertures too small to admit a man's body in any other position.

When these poor hewers, "holers," or "undergoers," have done loosening enough coal in any particular vein, the "putters" take the work in hand. They are usually very young fellows, whose business it is to load the broken coal into big corves, or baskets, which by dint of pushing and pulling they drag off to the more open spaces where it is possible to get the assistance of mules; for many of these useful animals are kept in the mine.

Some of them, indeed, never go out of it. Here they have stables, hay, and fodder; fresh water and corn are sent down every day, and a keeper looks after their health and comfort; so they are not so badly off as we might fancy.

We must remember also that habit makes their life in the mine endurable, and that the poor, half-blind creatures are doing good service in this dark underground world, where they relieve the "putters" of their heavy burdens of filled corves.

Having seen the coals hewed and "put," we follow our shadowy leader, to watch the great corves placed in the care of the "cranesman," who carefully numbers each load before seeing it laden on to the rolley, or wagon, which is to transport it to the bottom of the up-shaft. Here it is taken charge of by two young but strong-armed men, whose business evidently is to hook on the full corves and start them on their upward career, and to unhook the empty ones when they come swinging lightly down again after their swift upward journey.

As these loads arrive upon the platform at the pit's brow, the corves pass over a weighbridge, and the quantity which each contains is ascertained before it is emptied. Each fresh arrival brings with it a tin ticket, bearing the number of the hewer who has sent it up from the depths; and as the corve is weighed, a man appointed for the purpose calls out the number and the amount of coal answering to it. These items are set down carefully in a weigh-book, and that there shall be no chance of mistake, a check-weighman is always

on the spot to verify the weighing in the name of the absent underground worker. But when a railroad company handles many million tons of coal annually, weighing becomes a problem of importance. Skill and long experience have solved the problem, however, and the bulk of the vast coal tonnage of the leading coal-carrying road in the country, the Philadelphia and Reading R. R., is weighed on four scales, and then they are not crowded.

The weight of the empty car is marked in chalk on the outside. As the car approaches, a clerk takes the number of the car and its weight; the weigher calls out the gross weight, and the difference is the weight of the coal. The cars run as fast as ten miles an hour across a scale, and it is very seldom that a car has to be stopped and brought back for reweighing, although that is done when the weigher is at all uncertain about his figures.

The men at the scale can generally tell within a hundred pounds what weight of coal a car contains. As soon as they see the class of car coming, they know the number of tons it will hold, and they have the scale so prepared that only the hundred-weights need be adjusted while the car is moving over it. Expert officials of the company can tell at a glance about how many tons each car should

contain, and if, in looking over the weight-sheet, any car appears either too heavy or too light, it is brought back and reweighed.

The coal next undergoes a kind of sifting process in a large screen, somewhat resembling a monster gridiron, its bars from an inch to an inch and a half apart. All the pieces that fall through pass into another screen, to be sifted by dropping through its bars, which are only half an inch apart.

Even the remainder of mere coarse dust, or "slack," which is again sorted, finds a ready market, being used in coal-ovens, iron-furnaces, and for the manufacture of patent fuel of various kinds. Next, when sufficiently screened, the coals are tipped into a flat shoot, and thence fall clattering into the trucks which are to convey them by rail to various parts of the country.

We have not as yet been through the glorious domain of "King Coal." We have not done walking through his narrow roads, where the deeper we go, the hotter and more oppressive grows the atmosphere, though, in a properly regulated mine, it increases only at the rate of one degree for every sixty feet we descend.

Sometimes we come to a quite neat and shiny little black drawing-room, the walls of which are composed of layers and strata of ironstone, blue clay, and shale; but in other places we as suddenly

come to a spot where some poor "undergoer" is working in such a narrow "vein" that he has to lie sideways. We can see that he works painfully, making a long, narrow opening in the seam of coal, into which he drives his sharp iron drilling-tools as deep as they will go.

Then he toils with short, stout picks and hammers, over which he has not enough command for the task he has to do, for he cannot swing them as he ought. Having to use them without any proper leverage no doubt adds to his fatigue, yet on he has to work his weary way, loosening the coal as best he can.

Lesson II.

Dangers Below.

There are different modes of working mines, which our guide tries to make as clear to us as possible. In one method, — which can be adopted only with "thin coals," — as each "chamber" is emptied and cleared of its riches it is deserted, and the wooden beams or props — usually formed of tree-trunks — are withdrawn and carried away, leaving an empty space, that sooner or later falls in; often producing a kind of earthquake in the

land above, toppling over the poor little hovels built upon it.

In some parts of Pennsylvania there are districts where houses can be seen uncomfortably perched at every angle but the right. They are the wretched habitations of the colliers digging and delving below.

In straight or narrow drifts rough pillars of coal are left standing to support the roof. This is termed the "post and stall" method, and is so managed that all these posts or pillars of coal can be one day worked back upon, and be removed. We can stand up to look about us in the drift we are in now; but the noises we hear are alarming, until we are informed that those mysterious, hollow bangs, sounding like distant thunder, and filling the air with sulphurous smoke, are caused by workers "holing" the coal.

This operation, we soon find out, means that after the coal has been cut away some ten feet wide and five or six feet deep, the collier drills deep openings in the coal walls, as close up to the roof as he can get; then he carefully fills these holes with gunpowder, and next proceeds to blast them in such a manner that all the coal about them shall be shattered, loosened, and easily broken up into bits ready to be at once carried off by the putters.

Blasting is disagreeable labor, for it fills eyes and mouth with dust and smoke. No wonder that the men engaged in it speak in hoarse tones, or that they are more like dark spirits of the mine than honest mortals at their daily work.

On our way in and out of these mysterious galleries and chambers, our guide turns his light on many workers, who, to our unaccustomed eyes, all seem to have a sort of wistful and discontented look — though I believe that miners get to like their occupation ; indeed, there is a saying, "Once a miner, always a miner."

We meet with "shifters" and "wasters" and "way-cleaners," who, peering about, with their lamps gleaming like fire-flies, seem to be busy everywhere. We see men clearing away coal or shale that may have dropped on the railroad track — not a steam railroad, we must remember, but a mule railroad. Other workmen are sweeping and removing coal-dust, and keeping the galleries clear of obstructions which might cause accidents. Then, too, the lately cleared chambers must be watched, and be supported with sturdy beams of timber, lest their roofs should suddenly fall in, and should block up the passages near by.

A most important part of coal-mining is that relating to ventilation. The air in a mine should be kept as fresh as possible, and be constantly

noted and reported upon. Even with the best care and arrangements a great and unexpected increase of noxious gases sometimes takes place, owing to the sudden loosening and release of masses of coal.

It has happened, even in well-ventilated mines, that a single careless stroke has opened a cavity filled with a deadly gas. Probably neither you, nor I, nor any of those hundreds of toilers would ever see daylight again if the ventilation of this underground world chanced to be neglected or obstructed for a short time. Damp, unwholesome gases, gunpowder, and the breath of so many creatures, would soon become unbearable, and would cause suffocation. Even with all the precautions taken, over a thousand fatal accidents each year are computed to happen to the poor workers in the mines of the United States.

A large and increasing part of our population lives a hazardous and cheerless life underground. So little are we of this upper earth accustomed to dive below its surface, that in order to form an idea of the level at which a collier works daily, we must measure it by something above our heads. We must suppose our acquaintances on a level with the top of the Washington monument, and ourselves daily descending by ropes to our places of every-day labor.

We shudder at the thought of hardy islanders suspended over precipices in quest of birds' eggs. The collier's descent is often deeper, and his doom, should he fall, more certain. Should he miss a step at the brow, should the rope break in his descent, should a wheel in the engine be put out of gear, or a peg out of place, or should the keeper at the pit's mouth be inattentive for a moment, the next instant basket, rope, and man lie a crushed mass at the bottom of the shaft.

But that is only one danger, and not the greatest one either. The miner moves in an atmosphere into which a million chinks and pores distill a deadly vapor. The very air he breathes is a magazine of destruction. Wherever he extends his labors, he lays bare a new surface, and starts a fresh foe. In these upper regions the natural currents of air diffuse, and carry off all noxious gases as fast as they arise; but the natural atmosphere of those wonderful underground vaults is itself a poison, and air must be artificially introduced in quantities sufficient not only for human needs, but also for the expulsion of local gases. A strong current of fresh air must be brought down a shaft, be conducted through the whole mine, carefully sweeping every corner and recess, and be passed up another shaft to the surface.

If this current is insufficient, or is accidentally

interrupted, the foul vapors accumulate, and a spark, or a lighted pipe, explodes the whole mine, burning, suffocating, or tearing to pieces every living being in range. The explosion, which drives out by the pit's mouth the whole mass of air within, entails a reaction not less deadly. The "after-blast" finishes the work of destruction. The list of perils is not complete unless we add that everywhere are suspended over the collier's head vast masses of material ready to fall, and to bury him at his work.

Before the steam-engine helped to drain mines and to carry away coals, excavations were much more limited in extent. Then the spirit of each mine was generally supposed by the superstitious miners to be angered by the intrusion of mortals into his domains; and being lighter than the air, he often hid in the upper part of some chamber, that he might work men evil, as he could easily do, being invisible to all eyes, and to be detected only by fire, which is the weapon with which he destroys.

The poor miners were terrified at the enemy they found pervading every corner. They beat him off into the air, or, knowing no better way to defeat him, "fired" his principal hiding-place every morning. This firing was done by means of a light on the end of a pole, which some work-

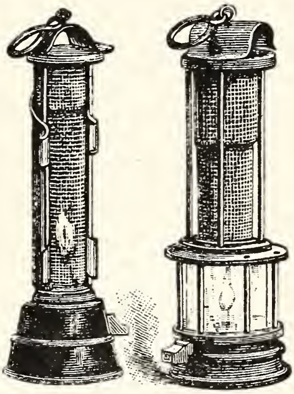
man, lying full-length on the rough floor, extended carefully towards the place where the evil thing hid.

Of course, the fire-damp instantly caught the small flame, blew a great angry blast, and vanished in flame, defeated for the time being. Its disappearance was a great relief to the prostrate miner, who usually donned wet clothes for the encounter, dreading to be scorched by the hot breath of his enemy.

But sometimes this same dreaded damp was too strong to be attacked by hand thus, and then the workman stood at a safe distance, and passed his candle slowly towards the invisible foe by means of a cord and a catch fixed at the other end of the gallery. This mode of exploding the inflammable gas was known as the "firing-line" explosive.

We have heard in this mine so much about the danger of fire-damp and explosive gases, that we look with lively interest at the ingenious little lamps we carry. Lamps of this make have saved many lives. The "Davy" and the "Clanny" are the kinds of safety-lamps most in use; and if the collier, that most reckless being, could only be persuaded to use them more carefully, and not to open them on every occasion when he wants to smoke a forbidden pipe, they would be of still more value in defeating the gas foe than they are at present.

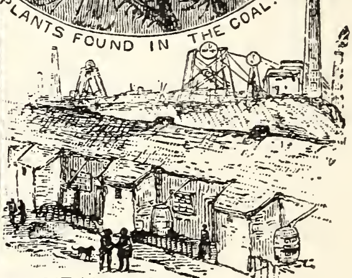
Sir Humphry Davy's invention is certainly very simple, and is easily understood. In it, the flame is surrounded by a perforated metal case of fine wire gauze, the holes in which are large enough to



DAVY LAMP. CLANNY LAMP.

PLANTS FOUND IN THE COAL.

THE FLOOR RISING.



A PIT VILLAGE.

allow the light to pass out, but not enough heat comes through to affect the air about; and, as we know, it is in this air that the explosive gases too often abound.

Sometimes, however, if a safety-lamp passes through fire-damp, some of this gas may get

inside; but there it will burn, for, happily, it cannot get out, nor do mischief to the bearer, although perhaps it will put out the light in the lamp, burning with a strange flame itself. Fortunately, this peculiar gas — scientific men call it carbureted hydrogen — is not to be met with in every mine, being more abundant in coal of the bituminous or caking kind.

We notice no fire-damp in this dry, well-ventilated mine; but our guide assures us that in some out-of-the-way corners, where the air cannot circulate freely, a great quantity of most peculiar-looking moss grows in masses, clinging especially to the timber beams supporting the sides and roofs. He describes it as more like soft, white wool than anything else, and says that at a single touch it drops, and vanishes like some magic thing. A noisome vegetation truly, and worthy of the fabled spirit of the mine, but not a pleasant thing for visitors to remember at present.

Suddenly we find ourselves directly under the upcast shaft which leads to the world of light and life. We fancy, as we peer up it, that we see a round piece of the blue sky, which we shall be so glad to greet again. But as we know that this shaft helps the ventilation — which is carried out by means of "brettice-cloths," or timber partitions, up one side and down another of which the air is

constantly traveling — we are content to step back and to follow our leader through a little open door, then along a close, muddy, dark passage-way, then through another little door, which bangs to behind us.

We find ourselves now standing in such a violent draught that we are glad to clutch our hats fast and to scamper across to the other side, where a tall, dingy fireman, lightly dressed after the manner of his kind, stands armed with a long iron rod, with which he is stirring up a roaring fire in a furnace. Near this is the wide, fire-brick chimney or shaft which carries the hot air up to the pit's mouth.

As we have learned something concerning colliers of to-day, let us here learn something about the underground workers in England in the era of King James I. Those poor men seem to have had very hard times, not only from the danger of the mines — for there were no kind of engines or safety-lamps with which to defy the supposed evil spirits of the depths — but also because miners during the reign of James I. were harshly treated, not being allowed to leave an employer without giving twelve months' notice.

When honest colliers began to get scarce, coal-mine proprietors were allowed to seize upon any tramp they met with, and to send him down,

willing or unwilling, to toil in the mines, to dig out coal, to attend to the pumps, or to clear the way, for as long a time as it suited unprincipled foremen, which might be a lifetime.

Terribly hard toil, too, was mining ; for the law decreed that "all cole-hewerers should worke all the six dayes of the weeke, and if any lyed idle they should pay twentie shillings for everie day not employed, and suffer other punishments of their bodies." This statute was but one of several hard laws, which remained unaltered until the closing year of the last century.

Lesson III.

Looking Backward.

What is coal ? It is the mineralized remains of a strange vegetation which must have grown and flourished for a very long period in remote ages of our world — when the conditions of the earth were entirely different from what they are now, and man himself had not yet been created.

The warm and humid atmosphere in which gigantic ferns, conifers, palms, and other like trees could grow everywhere, was not fit to be breathed by human lungs.

In those days there must have been one settled climate all the world over; for exactly the same kind of fossil vegetable remains are found scattered far and near. They are hidden away underground in all latitudes, from Spitzbergen to the center of Africa, from Greenland to Guinea. Everywhere the remains of this mysterious "Carboniferous flora" are found to be precisely of the same kind.

There can be no doubt that the vegetation of those times was something very different from what we can imagine growing in our temperate land. Indeed, such vegetation could not grow here *now*. Monster trees pressed close together with foliage that spread with marvelous luxuriance. Ferns, bushes, shrubs, mosses, and lichens — things that we now think of as pretty but insignificant — were then important parts of the landscape. Certain little weeds of to-day were then represented by tall trees not unlike giant asparagus plants, with buds springing up from the ground round about them.

What a wonderful sight a forest on such a scale would have presented had any mortal eye been there to view its marvels! In every direction spread crisp, green lycopods, such as we now cultivate as delicate little plants — insignificant but pleasing. Then, they were giants of the vegetable world. The mighty sigillarias rose until

they attained two hundred feet or more in height. Pressing closely about the monster stems, grew dense thicknesses of weeds of all kinds.

There might have been seen ferns and clumps of soft moss-like plants which caught and held moisture, while wreathing climbers flung their tendrils around trunk and stem, forming altogether a scene of which only travelers in the tropical forests of the East may get a faint image. There, in hot swamp-depths, are still to be found some of the same giant kinds of palms, aloes, tall water-rushes, and quaint-branched, many-leaved shrubs, half hidden in rank, tangled undergrowths of singular plants, which must in that dim old time of the Carboniferous era have been as common in Europe as anywhere else on the globe.

Yet, though those old forests must have been strange and luxuriant, their beauty could have been but unsatisfactory. The tall tree-ferns, with their lace-like leaves (three hundred species of ferns have been discovered), and numerous other trees and plants produced no flower or bud. Of blossoms there was not one, nor did there grow a fruit or a berry.

There was no man, no singing bird, nor other breathing creature on land as yet to need or to enjoy such things, and such things were not. The only signs of life were in the waters. Swamp

and pool and river lay hidden and overhung by giant green reeds, and there was but little life anywhere; perhaps a few strangely formed fish and two or three species of singular reptiles comprised all the living creatures.

The question suggests itself, if there was no human being alive in the Carboniferous period, how can the wisest teacher of the present day know what the world was like, or even be sure that such things as we have been describing ever existed at all? The coals, in weight or color, do not give the slightest clew to such a strange and unlikely history, and certainly in no way remind us of stately pines or waving palms or graceful ferns. Surely this solid, black, stony substance which we are so grateful for, and which we use to such advantage, never formed any part of green trees? Besides, how *could* anybody know of coal's origin now?

The answer to this question is read in the coals themselves; for in them hide seeds and clear impressions of leaves and fragments of woody stems. In the depths underground are sometimes found entire fossil trunks of just such trees as I have been picturing. They have not seldom been discovered clustering together in the very center of a bank of coals.

The Equisetum has been thus found in large

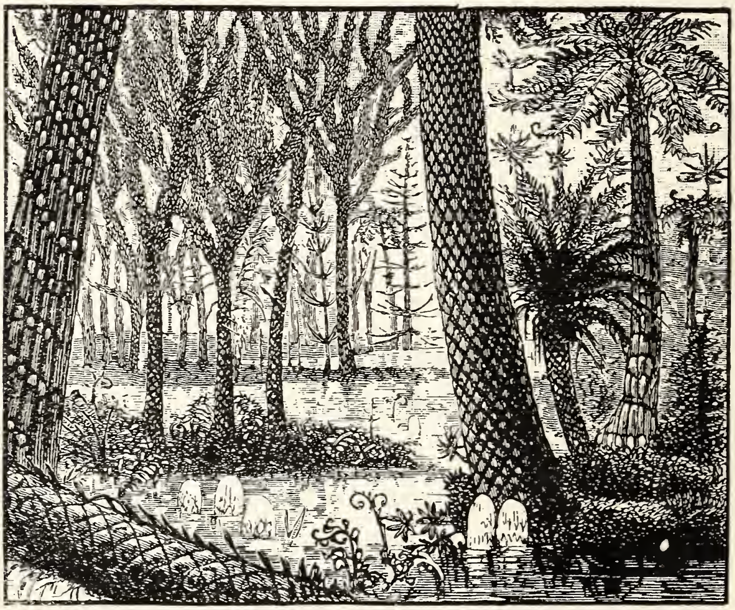
numbers, standing quite erect and free of its surroundings. In a bed of coal in South Staffordshire, England, within a quarter of an acre, there were discovered seventy-three stumps of trees, all their roots still attached to a seam of coal ten inches in thickness, and resting on a layer of clay two inches thick. Under all this layer was a second forest, resting on a coal-bed from two to five feet deep; and again beneath this stratum of coal lay a third forest, with large stumps still in the places in which they had grown.

In Nova Scotia there have been found in some coal-fields, which were 1,400 feet thick, sixty-eight different levels, presenting evident traces of as many ancient forests! The trunks of the trees still showed the roots which had held and nourished them when they spread fresh and green over the land.

It has been proved by actual measurement of existent coal-seams, that in the region now known as the United States, the forests of the Carboniferous period extended over more than 190,000 square miles; in Queensland, Australia, over 8,000; over 1,000 in France; and 500 in Great Britain.

But very much higher numbers are doubtless to be safely inferred; for it is believed that, in the case of Great Britain for instance, such forests covered all the ground, extending from the hills of

North Wales to land stretching far beyond the Channel which separates England from France — for the geologists tell us that the Straits of Dover did not exist even in the later wonderful Tertiary epoch which they portray.



Forest of the Coal-Age, or Carboniferous Era.

But, after all, how was it that those monster trees, those wide-spreading ferns, close-packed as we know they grew, ever became coal? By what wonderful process did their soft wood change into a hard, stony, black substance, without which so many homes would be comfortless, and industry would come to a standstill?

Strange — nay, marvelous — as such a transformation appears to be, a little explanation shows the apparent miracle to have come about in a way natural enough. Those dense masses of thriving vegetation, springing up rapidly in a close, moist atmosphere, as rapidly arrived at maturity; then they quickly faded, withered, and died. Their leaves were scattered in many a shower, then the trunks fell, the soft, swampy ground forming a hotbed upon which they soon decayed, changing into mere masses of vegetable matter, over which occasional layers of mud or clay were left by retiring waters.

It is evident, also, that after long ages this yielding surface must have sunk and settled somewhat, and that waters washed in, bearing great deposits of sand and pebbles, which formed hard layers of stony bands, compressing and holding fast the vegetable matter beneath. By a curious process of natural chemistry, the dead vegetation slowly but surely changed into what we call coal, as surely as the mud hardened into slate, while the deposits of sand and pebbles grew into rocks, as though more safely to hide the mysterious transformation going on beneath.

That there should be less doubt of the "how" of this strange beginning, we have but to examine some of these bits of the once soft slate which

has evidently pressed on the decaying trees over which it stole, drying so rapidly that it had time to catch many an impress of lace-like fern, of broken twig, or of ripe, dry seed, which, once modeled, was never to be effaced from the surface of the shale. Here we see the tracery as clear as though it had been made yesterday.

Yes, as geologists, in reasoning upon this strange transformation of mere vegetable matter into coal, remind us, we may find every gradation between coal and wood. We may see the forest growing in its bed of vegetable mold. We may see the forest dead and converted into peat, with stems and roots in it, and peat we can find transformed into lignite, or wood-coal ; then gradations between lignite and bituminous coal are to be seen in every coal-mine ; and gradations between bituminous and anthracite coal are common.

But, you may inquire, how is it possible, according to known natural laws, for vegetable matter to become coal ? The chemist answers this question by showing that wood can become lignite, or wood-coal, by parting with its oxygen in the shape of carbonic-acid gas, or what the miners call "choke-damp," and then the lignite can pass into ordinary bituminous coal.

This explanation sounds rather scientific, perhaps, but it really is very easy to understand ; and

it is as easy to believe that what *can* be done, *has* been done, in this great Wonderland of Nature which lies hidden under our feet. Yet, that all doubt should be set at rest on this important matter, experiments have been made to demonstrate plainly the process by which this mineral treasure was formed.

To prove how the transformation originally took place, an apparatus was used by which a mass of strongly compressed vegetable matter, placed in moist clay, was exposed to a long-continued warm temperature. The means used allowed the gases and vapors to escape, but to escape only in such a way that decomposition of the vegetal substance took place in warm, moist air and under heavy pressure.

By these means several very curious results were soon reached. Thus, the sawdust of different kinds of wood produced substances resembling various kinds of coal — some kinds bright and shining, others lusterless yet hard. This experiment seems clearly to explain the reason why coal is so often found in differing veins, varying of course according to the varieties of wood of which they were originally formed.

The period during which those primary forests continued to grow, to flourish, and to decay, is unknown, except so far as can be estimated from

the known thickness of various seams of coal in different parts of the world. In England there is a coal-seam thirty-six feet thick; and in Poland there is one of forty-eight feet in thickness.

How often forests were overflowed and destroyed by water spreading over a sinking area, and how often they again sprang into life and beauty when the water receded, and the ground was once more raised, are questions answered by the number of seams which can be counted in a section of the coal-measures. Each seam represents the growth of one of those apparently useless forests, which no man then enjoyed, but which are now storehouses of light and heat and resistless steam-power.

Of course all these precious deposits lay at first in flat, though hidden beds, until disturbed by volcanic movements from below them. These earthquakes shook and changed the coal-beds, sending some lower and raising others, at all sorts of angles, even above the surface. When visible, they must, we should imagine, soon have attracted the attention of mankind. Men, however, when mere hunters, cared more for such hard stones and flints as they could chip into weapons or hatchet-heads, by means of which they could kill their prey, or cut down for fire-wood the timber with which they were surrounded.

The woody nature of coal can be best detected in lignite, or brown coal, found in immense quantities in America, India, China, and elsewhere. We owe this coal to later periods, when forests sprang into being where once had been seas; these forests in turn leaving their deposits to be gradually buried in the sediments of other seas, or of oceans, which vanished long ages since. The hard, dry anthracite, of which there are vast deposits in Pennsylvania, is found in beds generally much more contorted than beds of soft or bituminous coal.

Yet both kinds of coal were certainly formed of the same unlikely materials, and in the same way — that is, by a certain amount of heat from below and pressure from above. In the anthracite regions, however, violent volcanic action going on in their close vicinity must at some far-off time have broken and unsettled the coal-measures, drying and hardening the coal, by draining and expelling the bitumen and oily matters it originally contained.

Lesson IV.

A Curious Error.

Let us pass from the mysterious Carboniferous period to that time in which coal first concerned our ancestors. While timber was plentiful, coal had but little chance of being appreciated; and it was not until the fourteenth century that the freemen of Newcastle, England, finding that the people of Edinburgh were trading in this black substance, thought of obtaining a charter giving them the sole right of mining and selling the hitherto almost valueless "coles" that lay buried in every direction about their city.

Thus arose a traffic in "sea-borne cole" — that is, coal "borne" by ship from Newcastle to other ports — but the prejudice against the new fuel was so strong that but little of it was bought or sold for a long time. Even when the dyers, fullers, and other workers would gladly have used it, as wood was becoming expensive, a great out-cry arose, people asserting that burning coal poisoned the air, and that the black mineral would certainly cause a pestilence in any neighborhood where it was consumed!

Then, as it still found more customers than

was expected, King Edward issued a proclamation sternly prohibiting its use to all but smiths, and not only fining those who persisted in burning such obnoxious stuff, but sanctioning the destruction of all buildings from which the dreaded coal-smoke should be seen to issue in defiance of law!

This stupidity is, perhaps, not so much to be wondered at when we remember that in those days of no chimneys, ordinary people warmed themselves at a "hearth-stone," on which they burned wood. Its smoke curled about their heads, or passed out of door and window when they chanced to be open. This nuisance could not be endured with coal-smoke; chimneys had to be built, and houses had to be altered to allow the chimneys to be added, and this necessity was looked upon as a grievance.

One fault-finder of the time wrote indignantly: "There bee old men yet dwelling in the village where I remaine, whiche have noted the multitude of chimnies latelie erected, whereas in their young daies there were not above two or three, if soe manie, in most countrie townes of the realme, the religious houses and manour-places of their lordes alwaies excepted; but eache one made his fire against a reredosse" (an open fireplace without a grate).

In the early days of Queen Elizabeth the laws remained so stringent on this subject of coal-burning, that a few shiploads of coal passing from Newcastle to London represented the traffic in the despised treasure. When later on its value began to be better understood, we read that it must never be burned during the sitting of Parliament, lest its fumes should affect the health of country members, used to wood or charcoal !

A writer of that period tells us of "the nice dames of London, who would not come into any house or roome where sea-coles were burned, nor willingly eat of meate that was either sod or roasted with sea-cole fire." Thirty years later the same writer bewails that, through the great "scarcetie of wood, the inhabitants of the Citie of London," as well as others, "are constrained to make their fires of sea-cole, or pit-cole, even in the homes of honourable personages ; and through necessitie, which is the mother of all arts, they have of verry late yeares devised the making of iron, the making of all sorts of glasse and burning of bricke, with sea-cole or pit-cole."

Very surprising ; yet I wonder what these same "nice dames," or even the devisers of iron, would have thought could they have known that in 1890 9,000,000 tons of that metal would be smelted by means of "coles" in the United Kingdom, and

that its mines would furnish 170,000,000 tons of coal to be used in manufactures, and on railroads, in gas-works, steam-navigation, mining, and for household requirements and comforts. Yet, as perhaps this large number of tons may give but a poor idea of the quantity of "coles" they represent, let us imagine all this coal built into a wall, thirty feet wide and thirty feet high. This wall, if commenced in London, would reach to Rome. Let us note that, as the population of England increased, and as forests began to disappear, the English people began to find that "sea-cole" must be endured; next they realized it was a very good and useful thing, and did not kill off persons as fast as might have been expected. Still, its progress in public favor was so slow that it was only when the steam-engine was invented, and gaslight became common in large towns, that a revolution in fuel-using took place in manufacturing. Mines were then opened in every direction, and an immense and profitable coal-trade was developed.

Cannel-coal is very much patronized by the gas-makers, because they can extract the best gas from this particular kind of "black diamond," which breaks easily into dry lumps, somewhat resembling jet, which is one of the lignites. In the Paris World's Exposition there was shown a great,

well-polished cup, sent by the English Turners' Company, as a specimen of their skill with the lathe. No doubt it was a very difficult piece of workmanship to execute, as coal is so brittle that without the utmost care it will fly off in every direction, when cutting it is attempted.

Of course we all know that the value of coal depends upon its combustible properties. Of its use as mere household fuel I need not speak now; but as our great manufactures and mining works are dependent on it in the form of the mighty power it aids in producing, I may as well tell something of the strength to be obtained from coal as represented in the never-tiring steam-engine.

A scientist who has tested the power of steam, that giant spirit of all work, compares it with the task done by a man on a treadmill. Reckoning that a man weighing 150 lbs. (about the average) lifts, on a treadmill, his own weight 10,000 feet in a day, he raises one pound 1,500,000 feet in that time. One pound of coal would represent that day's work.

Our authority next estimates a period, often a lifetime, of hard muscular toil, lasting for twenty years. Reckoning 300 working days to the year, there are altogether 6,000 days, or 6,000 lbs. or three tons of coal as represented by steam-power. Therefore, we can but come to the conclusion that every three tons of coal is the equivalent of one

man's muscular activity for twenty years — a fact which must make us feel a sort of wondering respect for this mineral, every cubic yard of which (solid) weighs over a ton. A block of coal twelve feet high, the base only a yard square, has more "work" in it than many a man's life-labor.

Lesson V.

Light From Stones.

If we could ascertain the use of a certain large quantity of all the coal which is mined yearly, we should find that it is converted into gas. Several million tons of coal are annually needed to supply our great cities with light.

One ton of good coal, which represents, as we all know, 2,000 lbs., produces about one chaldron of coke, several gallons of tar and of ammoniacal liquor, and 9,500 cubic feet of gas, each cubic foot weighing 514½ grains. Now let us see how all these products are disposed of for the benefit of the public.

The gas, or carbureted hydrogen, which is extracted from coal by distillation, leaves behind it that gray calcined substance well known as coke, some of which will most likely be used in

blast furnaces (it takes about 20 cwt. of coke to make a ton of the best iron). The remainder is sold to various metal-workers, or else is broken up and burned with coals in our own kitchen fires.

The gas-coal which is likely to be either caking or cannel-coal, is first placed in "retorts," or vessels lined with fireclay ; they are some six or seven feet long each, one and a half broad, and one foot high, and they stand nearly five feet from the ground. They are built in with firebricks. Several of these retorts are arranged in such a way that they can be heated by a furnace below, whose flames surround them all with an intense heat.

We see a strange sight, if we glance into one of these retorts, should it be opened to show the fierce, glowing mass within. But as the supply of coal is put in, the mouth of each vessel is at once closed, and made air-tight with wet clay. Each retort has an iron tube projecting from the oven ; the tubes are intended to convey the gas into the "hydraulic main," a large, horizontal, iron pipe, half filled with water, into which all the smaller tubes pass.

This receiver is connected with the tar-well below, and into this well the tar and liquid ammonia that condense from the hot gas will fall and settle. Owing to the greater gravity of these fluids, they can by means of a simple contrivance be drawn off, and after certain treatment they take

their various places in the world of commerce, as gas-tar, naphtha, ammonia, and other marketable things.

For the present let us follow our coal-gas, which, being a gas, instead of descending into the tar-well, passes up into a curious apparatus called the "condenser." This consists of a series of curved upright pipes, joined at the top, and standing in pairs on a kind of large cistern with which the ends of each pair communicate.

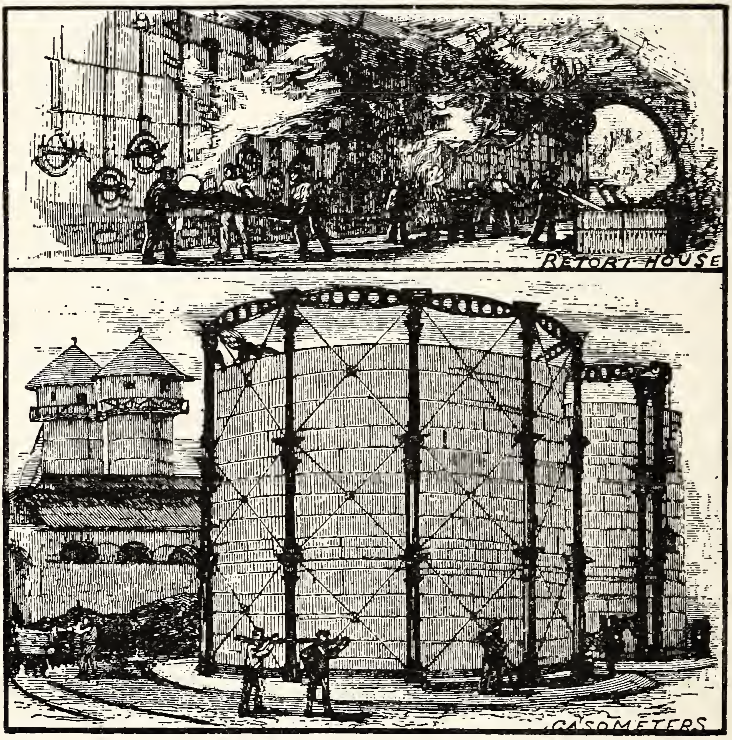
From the center of the bottom of each pipe a metal plate passes almost to the bottom of the cistern, and hinders the hot gas from at once passing through the cistern as it would naturally do. Therefore, the gas rushes up the first pipe it meets with, then down the other side; then it goes flying up the next pipe and descends again, and so on until it has traveled through all the pipes.

As they are kept very cold, either by means of air or cold water, the hot gas chills on its way, and leaves behind all the liquids it brought with it from the retorts. These liquids left to themselves, thicken and condense, and finally fall into the cistern below, from which they are passed, by means of a pipe, down into the tar-well.

But there is another objectionable thing still vitiating the gas; its name is "sulphureted hydrogen." This has to be disposed of, as it is a most

nauseous and unwholesome gas, and owes its existence to the iron pyrites found in almost every kind of coal.

There are two ways of purifying coal-gas, the usual one being to pass it into a broad, perforated,



Making Gas.

iron cylinder through a pipe which is lowered into an air-tight reservoir partly filled with lime and water kept well stirred by revolving metal arms. Into this "cream of lime" the gas passes, and as it leaves the mixture thousands of angry little

bubbles rise as though in protest at such an intrusion.

But the lime attracts and retains the things which it is so desirable to get rid of, and the purified coal-gas rises to the top of the reservoir. Having been measured by a "station-meter," the gas will then be passed into the gasometer, where it remains prisoned until required. Nowadays, gasometers — or gas-holders rather, for they do not *measure* gas — are usually to be seen in only the poorer quarters of cities.

Gasometers, as they are commonly called, are well worthy of notice, for they are generally made of iron plates riveted together, and resemble two monster tumblers — one always slightly smaller and fitting into the other. The larger or under one is merely a round, open tank, of cast-iron, or perhaps of brick, lined with fireclay, and nearly filled with water.

From the bottom of this tank a pipe ascends, intended to admit the gas into the empty space left above the surface of this water; and the upper half of the gas-holder, which dips into the lower half so as to cut off all air, holds the gas. This gas is pressed down by the top part of the gasometer, and so is forced through the main pipe, which also descends through the water.

When the gasometer is quite down, we may

conclude that it is empty, the inside of its top resting on the water with which the under half is, we know, filled. As the new-made gas enters, we may observe the huge top-half, which is suspended by chains, gently rising; and, watching it until it is filled, we presently see all of it except its lower rim. That rests a few inches below in the water, where it is held by the shape of its frame, which, expanding at the edge, keeps it from ascending above the water in the tank, and allows no escape of the gas within.

When night comes on, and a portion of the contents of the gas-holder is required, the upper half slowly sinks down by its own weight, and thus presses on the gas between it and the water, forcing the gas through the tube and into the main pipe. Through this pipe, the light-giver, so skillfully extracted from black stone, will soon go streaming in every direction. How few of us waste any thought upon what a wonderful slave gas is — ready at one instantaneous touch of fire to spring into visible existence, and to light streets and buildings!

Evening is a very trying time for the attendants of the big gasometers, as great care and attention are required to supply the sudden demand for light; the gas has to be evenly distributed at the farthest point to which the service-pipes extend. To do

this work, the gas stored in these big cylinders must receive a certain pressure, and to give the right pressure requires experience and care.

Inquiring into the history of coal-gas, we find it first mentioned about two hundred years ago as a strange curiosity, which was chanced upon by Robert Clayton, who, it appears, first distilled a few coals, and obtained gas from them.

He wrote: "I kept this spirit (gas) in parchment bags, and when I had a mind to divert strangers or friends, I have frequently taken one of the bags, made a hole therein with a pin, and gently compressing the bag near the flame of a candle till it once took fire, it would then continue flaming until all the spirit was gone; which was the more surprising because no one could discern any difference in appearance between these bags and those filled with common air."

No doubt Clayton's strange experiment was much talked about and puzzled over at the time; but though it was communicated to the "Royal Society" as worth that august body's notice, we do not hear that any particular effort was made to forward the discovery as a matter of general importance. Later on some few acute minds believed in the possibility of illumining houses with this new light. Others ridiculed the notion. Many learned men opposed it, even were it practicable,

on the ground of the danger and expense such an unlikely method of obtaining light must involve.

Yet they were in the wrong, as modern experience has proved in the most satisfactory manner. As yet gas has provided the cheapest and safest light.

Nearly the first authentic notice we have of the gas of pit-coal being practically used for lighting is in connection with certain ingenious experiments made by William Murdoch, a clever and gifted man, of whom I must tell an interesting anecdote.

One day a poorly attired young Scotchman applied at a Birmingham foundery for work. He was shown into the office of Mr. Boulton, one of the firm, who was a shrewd observer of character, and so thorough a man of business, that people styled him an "iron king." A young Scotchman in search of a situation was no uncommon visitor at the foundery, and as there chanced to be no need for the services of inexperienced youths, this one was very soon summarily dismissed.

"No vacancy, young man" — words soon said; but though spoken in kindly tones, they fell on the stranger's heart like lead. He and his were poor, and they had been so hopeful, and he had made such efforts to reach Mr. Boulton, all for nothing. The busy head of the firm had scarcely

looked at him, had only flung over his shoulder those hard words, "No vacancy." The young fellow, loath to accept a dismissal, stood nervously twiddling his hat for such a long time, that Mr. Boulton at last turned impatiently to survey the troublesome petitioner, perhaps to give him a more decided refusal.

At any rate, he turned and fixed his eyes inquiringly, not on the youth's disconsolate face, but upon the hat that the young man was turning about and smoothing every way with his red and awkward fingers.

What a hat it was! smooth, hard and black and as round as a metal pipe. People in those days wore beaver, and there was not the same variety of head-gear as there is now. Otherwise, perhaps, Mr. Boulton would not have been so struck by the appearance of that hat as to inquire what it was made of, instead of repeating his last unwelcome remark. He held out his hand for the peculiar article that had so suddenly excited his wonderment.

We can fancy how the bashful Scotch lad blushed up to the roots of his hair, partly with mortified pride, partly with honest satisfaction at the evident interest taken in his work by the great merchant; for the hat really was his own work. It was made of wood and had been turned

in a lathe, because he could not afford to buy anything new of the kind, and he had been told he ought to wear a "top" hat, not a cloth one, when he came to ask for a situation in the big forge.

Not that he had ever seen or heard of a wooden hat before, but he had nothing but wood to make a hat of. Yes, it had been rather difficult to turn in a lathe, he confessed; besides, before he could make the hat he had to make a lathe. No one showed him how to do that task, but he had managed it somehow. The lathe worked pretty well, he thought, though he meant to improve it yet.

Mr. Boulton listened patiently to the lad's simple history of the ugly black hat and the lathe, to him a record of difficulties overcome by patience and ingenuity. Then, instead of repeating "No vacancy," he engaged the overjoyed youth to fill some humble position. The shrewd iron king had made no mistake; the ingenious head and the ready hand were there, suited, as he thought, for greater tasks. We next hear of this same young Scotchman, William Murdoch, engaged in fitting and rectifying the large engines for which the foundery was famous.

The day came when his kindly master could say, "We want more Murdochs." It was this same William Murdoch who, in 1792, first thought of utilizing coal for the lighting of his house

and offices at Redruth, in Cornwall. He made plenty of experiments, no doubt, before he was able to imprison the coal-spirit of light in a gasometer, from which he finally carried pipes to the different apartments, pipes with holes in them that could be opened or closed at will.

Lesson VI.

Valuable Waste.

The ammoniacal liquid which is one of the results of gas-making is first emptied into iron tanks in chemical works. It is then put into vessels, in which by means of heat it is volatilized, and after passing through large, coiled pipes, it condenses in a cistern in which it is received.

It is next treated with hydrochloric acid, and the solution thus obtained is passed into iron pans, in which it slowly boils until it is ready to crystallize ; then it is run into coolers, where it ultimately forms into crystals of crude salt of ammonia.

This is afterwards refined by a variety of processes, the most important of which is "sublimation," to effect which the salt is slowly dried, and is then placed in iron vessels with dome-like

covers. As the heat reaches it, the salt volatilizes and rises in the covers, gradually incrusting them with crystals of sal-ammoniac. This mineral can be removed in cakes, and be broken up as required by the various artisans who use it. A great quantity, we are told, is exported to Russia, where it is used by the peasants as a substitute for common salt.

One other use this extract of coal has, which you will never guess, unless you think of strong smelling-salts—carbonate of ammonia. A great quantity of ammonia is also used in dye-works, it having a peculiar effect upon vegetable colors. Ammonia is in the air we breathe — in fact, life could scarcely exist in the absence of this chemical.

It was known long ages before gas was heard of. Its very name is said to be derived from its manufacture in a district in Lybia, where Jupiter Ammon was worshiped. In ancient days it was obtained by the distillation of deer's horns. This mode of procuring ammonia reminds us of that pungent preparation of it still known as spirits of hartshorn.

Now that we have seen how from coal we get coke, gas, and ammonia, let us inquire what has become of the tar. If we ask some skillful chemist the nature and uses of this unpromising-looking material, he will tell us that it is "a highly

complex mixture of various compounds of carbon and hydrogen."

Very true, no doubt, but this answer does not explain to us what we want to know — namely; what place does tar fill in our Wonderland, where coal and its other constituents hold important positions? Strange to say, at a not very distant time coal-tar had no place worth mentioning. This unavoidable residue was looked upon by all owners of gas-works as mere noxious refuse they would be glad to get rid of.

Yet now this "waste" is proved to be very valuable. Carefully analyzed, it has already produced over fifty distinct and serviceable things. Among the most important of these we may reckon "benzol," from which, by further treatment, are obtained brilliant crystals which yield the aniline dyes so helpful to workers in several industries. The uses of crude benzol we are most of us well aware of; for we have seen it on boats, wooden walls, and palings.

Touched by the chemist's wand, it is transformed, and the sticky black-brown mass is dissolved into various substances, such as naphtha, creosote, which serves for the preservation of railroad sleepers; and ordinary pitch. The appearance and smell of this last compound most townspeople have become well acquainted with through asphalt

pavements and roofing. We can find pitch by tubfuls in any shipbuilder's yard, where timbers and ropes seem saturated with this black and sticky material, which is employed to make them waterproof.

Naphtha, which has several names, has also many uses in our Wonderland. Besides furnishing clear light, it acts as a solvent for fatty substances. Chemists use it for the preservation of certain metals; but it is especially of service in the manufacture of india-rubber and gutta-percha. These gums are now of the greatest importance in commerce; of them are made numberless objects, from a baby's teething-pad to the coating of the Atlantic cable, from railroad-bumpers to elastic threads.

Then comes paraffine, another production of coal-tar; its curious name is made up of Latin words which signify that it has little or no *affinity* for other substances. Its discovery was singular, and we owe it to "a man with eyes." This man was one day peering about in a coal-mine in England, and he chanced to notice that a thick, oily-looking fluid was dribbling from cracks in the roof. A skillful chemist examined this strange substance, and distilled two useful things from it — the first one was a light oil fit for burning in lamps; the second was a thicker, coarser oil suitable for lubricating machinery.

Both of these articles found a ready sale, yet after a time the original supply began to run short. Fortunately thinkers had come to the conclusion that this paraffine was produced through the distillation of coal by subterranean heat; the natural process was imitated, and large quantities of the same kind of liquid were easily made.

Lesson VII.

In the Air.

One curious sight we may sometime chance upon in the neighborhood of a gas-holder — that is the filling or inflating of a great, baggy mass of soft material which is gradually assuming the graceful form of a balloon. We are told that, to save the trouble and expense of making pure hydrogen gas for the purpose, — as once had always to be done, — our aeronauts are very glad to obtain from the nearest gasometer the large supply of gas they require. From the gas-holder it is conveyed by means of long tubes to the mouth of the balloon.

If we examine the half-prostrate object, we can see that it is fashioned out of long strips of silk, which are sewed strongly together, and are

then made air-tight by means of a coating of caoutchouc. A valve worked by a spring is fitted to the top or roof of the apparatus. This valve has a long rope which reaches to the car. The aeronaut can lower his balloon by opening the valve, thus letting out some of the gas.

The air-ship is now slowly but surely distending its huge round body, and displaying its showy colors and inscription, as well as stretching the strong rope network which covers it all over, and supports the car which is to carry both passengers and ballast — the ballast consisting of sacks of sand. Quantities of this sand will be thrown overboard should this strange vessel seem likely to land on any undesirable place.

As the silken globe begins to fill with gas, it shows symptoms of an inclination to be off on its travels ; but is held fast by many ropes. We cannot help noticing what a very different thing a balloon down here is, to what it appears to be when it is sailing far overhead, sometimes such a mere speck in the sky that we scarcely recognize its peculiarly curved form. Yet, an ordinary balloon with power to carry three of us up into cloudland, with all the ballast and other things required for our air journey, would weigh, with the silk net-work, and car, about 330 lbs.

It would be almost fifty feet high, thirty-five in

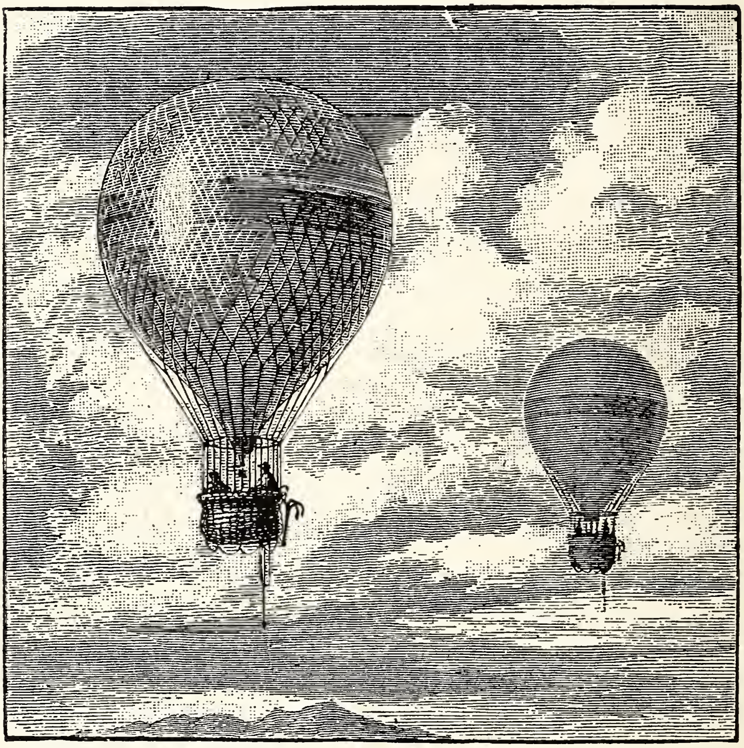
diameter, and would contain about 2,250 cubic feet of gas. A balloon is never entirely filled, because the atmospheric pressure, diminishing as the air-ship rises, allows the gas to expand; and unless there were room for this expansion, the balloon would burst, and death and desolation would ensue. Such an accident has been known to happen, even before the balloon was much higher than the gas-holder. We can fancy the horror of the onlookers at such a catastrophe.

Just about a hundred years ago the first gas-balloon ascended in Paris. Hydrogen gas, or, as it was then termed, "inflammable air," had lately been discovered by Cavendish; but its powers were not understood until Dr. Charles applied it to inflating balloons, believing it to be much lighter than hot air, the medium which had hitherto been employed. Finding his first experiments successful, he at once set to work to construct a larger balloon of taffeta.

From what we read, the inflation of that wonder-causing balloon must have been a most exciting affair; very different to the matter-of-fact proceeding that we are watching here to-day, under the shadow of the huge gasometer so silently doing its work.

First the gas had to be provided, and the supply of hydrogen was no small or inexpensive matter —

1,125 lbs. of iron and 560 lbs. of sulphuric acid being found necessary to yield the gas required to inflate this wonderful object, which after all could lift a weight of 22 lbs. only.



Balloons.

The hydrogen was produced by placing water and sulphuric acid, shavings of iron and of zinc in different casks, which communicated with one another by means of tubes. These tubes ran into a central cask. The open end of this cask rested

in a copper pan full of water; and the required gas was produced by the action of the water and sulphuric acid upon the zinc and iron. The gas in passing through the water in the central vessel would throw off all foreign matter, and be quite pure when it was passed into the balloon.

When the part filling of the balloon had been achieved, it was carried to its starting-point in triumph. The means of conveyance was a cart, and Dr. Charles's greatest fear was that the gas with which the balloon had been charged would escape on the way. The new air-ship was removed at night, being preceded by a torchlight procession, and followed by an armed and mounted patrol to keep off the thronging crowd.

Once safe at its journey's end, the balloon was fixed and held fast by strong cords, chains, and iron rings set deep in the ground; then, in the presence of many scientific men, a final inflation took place in a small park in Paris, under the wondering eyes of thousands of people, kept in order by troops who guarded the park on all sides.

All being ready, a cannon gave the signal, the restraining cords were unfastened, and, to the delight and wonderment of the multitude, off shot the balloon right up and away into the skies, followed by long cheers from the immense throng present.

Up and up it sailed, soon to be lost in a cloud, then re-appearing, to be missed in still higher space. Never, surely, has balloon caused such excitement from first to last; yet it was a mere toy to the one now before us, being only twelve feet in diameter, thirty-eight feet round, and containing only 943 cubic feet of gas. Its weight was but 25 lbs. In these days we should consider it a plaything.

In a very short time this admired silken marvel had sailed away out of sight. It traveled on bravely until it came to the open country far beyond Paris, where some peasants were busy at their harvest work; and there, because of the expansion of the gas, with which it had been too thoroughly filled, the wonderful piece of apparatus suddenly burst, and dropped shattered on the ground!

Who can paint the horror and affright of the superstitious peasants when this fearful thing from the sky fell among them? Some of them shrieked and fled for dear life; others ran at the enemy with flails, stones, and pitchforks, and beat, mauled, and hammered the thing, especially when they found that it did not resist their onslaughts.

At last they tied it to a horse, and dragged it about in the mud; so that when the disappointing news of its accident reached Paris, and search was

made for its remains, only a few torn fragments could be discovered. And the peasants boasted loudly of their courage in destroying it!

As nothing more could be done in this sad case, the Government published a long decree for the benefit of ignorant country folks, solemnly warning them against "kidnapping air balloons," and bidding them not to be again afraid of any "black moons" they might see in the sky, as they would be only silken bags filled with gas, and would be quite harmless.

But as this first attempt served to show that gas could carry up balloons, other "moons" were therefore soon fashioned, some of which were great advances on the first one. Yet it was some time before any one dreamed of risking his life by going up in such a hoister. The first experiment on living creatures was tried upon a sheep and some pigeons. They were safely carried up about 1,700 feet, being secured in a dangling osier cage.

If you ask why does gas fastened tight in a silken bag carry it skywards where nothing else would take it, I must answer by quoting a principle of physics: "Every body plunged into a fluid loses a portion of its weight equal to the weight of the quantity of fluid it displaces."

Thus, a body plunged into water is acted upon by two forces — its own weight, which would sink

it, and a resistance, which bears it up. This principle applies to air as well as to water, to gas as well as to liquids. Any object weighed in the air does not weigh its true weight, which is its weight plus the weight of the air it displaces. If any object heavier than the air it displaces be thrown into the air, such object falls at once. If it is of equal weight, it simply floats, but if lighter, it rises until it meets air of less density than itself. Balloons filled with gas rise because they are lighter than the air they displace.

Lesson VIII.

Old and New.

If we pass at night through noisy, crowded streets, full of light and life, we cannot help considering what a dreary change it would be if we had to return to the lighting arrangements of a century ago. Then, at night-time, the streets of cities were illumined by only a few horn lanterns, which the principal householders were obliged to hang before their doors.

People were warned by ancient watchmen, to fulfill this duty. Those old-time guardians of the peace trotted round the streets, and stopping here

and there before a door, called out, "Lanthorne and a whole candell light! Hange out youre lights heare!" But the spare rush "candells" gave poor, unsteady light, and usually flickered out in a short time.

It was considered a very great advance when a few oil-lamps began to twinkle in the principal streets of New York, Boston, and Philadelphia. These lamps were at last adopted in all the leading thoroughfares of great towns, and the expense, instead of falling on private persons, was defrayed by a regular lighting-rate, levied on all houses.

The employment of watchmen, one of whose duties it was to call out the hours, was at one time general in London, and took its rise in Germany. In the 17th century the watchmen went about the streets in the night-time, not so much on account of thieves as on account of fires and other alarms. When the clocks struck, each watchman was obliged to call out to another one, and to ask him what o'clock it was, and then to wish him a good-night.

Before the appointment of watchmen who patrolled the streets, men were stationed on steeples by day as well as by night; and these look-outs, every time the clock struck, were, each one, obliged to give proof of his vigilance by blowing a horn. The Chinese are said to have been accustomed, as early

as the 9th century, to have, posted on towers, men who announced the hours of the day and the night by striking with small mallets upon suspended boards. In St. Petersburg men were formerly stationed in various parts of the city to tell the hours by beating on iron plates.

Street-lamps were in time improved. At first they swung on ropes, but later the lamps in our grander streets were fixed to iron posts made for the purpose. Doorways of mansions in aristocratic localities often had lamps of very elaborate workmanship of wrought-iron. At many of the gates of old European castles we can still see large, trumpet-like extinguishers, placed handy for the extinction of the torches, which were carried on dark nights by footmen standing behind carriages, and were flourished as protection against any evildoers who might be abroad.

Some solemn old neighborhoods in English cities were for long in semi-darkness when night came; for their inhabitants declined to avail themselves of the benefit of gaslight while they could enjoy the dismal oil-lamps of their predecessors, and be nightly roused by the rattle, or the cracked voice of some passing watchman, who continually disturbed their rest to tell them "what's o'clock."

Yet it must have been a rather selfish pleasure for people comfortable within doors to hear a dole-

ful announcement outside of "past two, and a windy morning."

Gas stole into Pall Mall Street, London, in 1807. Shortly afterwards, the citizens ventured upon lighting up Bishopgate Street in the same manner, in spite of repeated warnings as to the fearful consequences which must ensue; for many persons believed that when a number of gas-fires were lighted, those stray folks who were not poisoned by noxious vapors must all be blown up by the many explosions sure to follow in every direction.

There is another sort of light which is now rapidly gaining ground, and which is produced by the aid of electricity. The arc system of electric-lighting is especially adapted for large buildings, lighthouses, docks, ships, and open spaces which require thorough illumination — such as broad squares and city parks. The electric light is far more powerful than gaslight.

There is another electric light which differs widely from that of the electric arc, and is known as the "incandescent" system.

If a powerful current is sent through an imperfect conductor, it makes the conductor glowing hot. Platinum wires are generally used as conductors; but the best incandescent lamps use very small slips of carbon, which have to be inclosed in globes from which the air has been exhausted, in order

that the carbon threads may only glow with the heat, and not burn away. This electric light is much softer than the other. It is hoped that ere long this beautiful light may be successfully introduced even into private houses, and be furnished as cheaply as gas is supplied now.

But the best system has yet to be determined, so many points having to be considered before deciding the question, and improvements are made in one point or another almost every day. Six different systems of electric lighting have recently been tried upon a large scale in the streets of London alone.

Lesson IX.

Iron.

If you wish to know the whereabouts of the valuable metal we are about to track through our Wonderland, let me tell you that, fortunately for mankind, it is the mineral most plentifully scattered about the world. This metal, which we call iron, lies deep-hidden in the sands and clays under our feet; it lurks in the pleasant spring waters we drink, and it enters into the composition of the plants and living creatures about us.

In fact, iron is everywhere, and may well be

considered "the metal of civilization," for of it are fashioned the needle and the cannon, the pen of the writer, and the sword of the warrior.

Without iron man could not plough, reap, shoe

Iron-Works.

his horses, or construct a railroad; the workman would have no proper implements with which to labor for his own and others' benefit, the seamstress and tailor no means of shaping or making our clothing, the surgeon no supply of needful

instruments, the helmsman no compass to point out the way he should steer.

Gold and silver and precious stones we might manage to live without; but iron we *must* have, for it is the material from which thousands of things necessary for civilized life are made. It can be melted and cast into a multitude of articles. It can be hammered and rolled into large, flat plates to cover mighty ships of war, or into slighter plates to make boilers.

It can be drawn into wires, some stout enough to twine and twist into cables strong enough to sustain the enormous weight of the Brooklyn Bridge, or into wires fine enough to snip into tiny needles. Iron threads are spun out the one hundred and fiftieth part of an inch in thickness.

Iron can be employed to build mighty steam-engines, or it can be wrought into carpet-tacks. It stretches far a network of lines, on which messages can travel all over the country. In short, iron is a necessity of modern life. Rich or poor, we all are equally indebted to this invaluable metal.

Under one form or another it aids man to earn his food. Iron helps to strengthen him if he is weak, to defend him when he is attacked, to build him a house to live in, to supply it with needful things, and to give him the means to travel rap-

idly and comfortably, either by sea or by land. We use this wonderful metal

> "To fashion the cannon that roars in the battle shout,
> The anchor, and the nail."

Surely, then, next to King Coal we may rank King Iron.

When, far back in the dim recesses of old times, men discovered a rude way of smelting iron-ore, they made their first great stride in civilization, besides extending their dominion over the brute creation. No doubt they treated the ore in much the same way that the modern African smith works iron-ore. He builds a clay furnace, through which air is allowed to pass, to produce a draught, and then puts in layers of broken iron-ore and bits of charcoal. Some smiths in the interior of the Dark Continent do without the clay furnace, and manage to smelt their ore by means of charcoal alone. The metal thus produced is easily bent, beaten, and worked into the required shapes.

Dr. Livingstone says that some of the tribes he met thought English iron rotten stuff. He had himself seen a spear-like weapon of their own make curl up, reed-fashion, when it struck the hard, bony head of a hippopotamus; but the owner of the spear soon straightened it out again,

as a matter of course, with the help of two pieces of rock and without any fire.

We feel a sort of pitying interest in the rude iron-work of uncivilized nations, forgetting that the Britons, Saxons, and even the far more civilized Romans, worked their metal in very much the same simple fashion, — a fashion which indeed continued down to modern times. For remember, it is not long since the power of water was the sole natural force that aided the industry of man. Iron-works, perforce on a small scale, were built usually on the banks of streams ; and it was only when steam came to turn wheels as by magic that Workland was changed.

Many remains of extensive Roman iron-works, or "air bloomeries" as they are called, have been discovered in the North of England. One of these may be thus described: Two tunnels were formed in the side of a hill, each wide at one extremity, but tapering off to a narrow opening at the other, where they met in a point. The mouths of these channels opened towards the west, from which quarter a prevalent wind blows in the valley, sometimes with great violence, so that the blast of air received by them would, when the wind was high enough, be poured with considerable force and effect upon the smelting furnaces at the extremity of the tunnel.

But there can be no doubt that, however cleverly managed, such chance blasts were not to be depended upon ; and this fact must have first suggested the idea of stationary bellows, then of some kind of huge fanner which should force wind into the furnace. The fanning system is still employed to keep up a draught in cupola furnaces, though it is of no value for blast-furnaces, wherein "blowing-engines" are used.

To what part of the United States shall we turn that we may see the modern method of preparing iron from its first to its last stage? I read in a newspaper of the day that in Pennsylvania alone 4,500,000 tons of iron are annually produced.

If we would know more, let us hie away to this "Black Country" where "the forges glow, the hammers all are ringing," and where we shall find a great iron-producing district of the most interesting kind, — a district which has only of late risen to importance. Fifty years ago western Pennsylvania was a wild and forlorn region with a scant population. Now that section is alive with workers, — a regular hive of bees, whose honey is of the most useful kind, but whose labors are of the hardest.

Coal and iron, iron and coal: these two mineral treasures have cast their shadow on what was evidently a thickly wooded part of the State, though

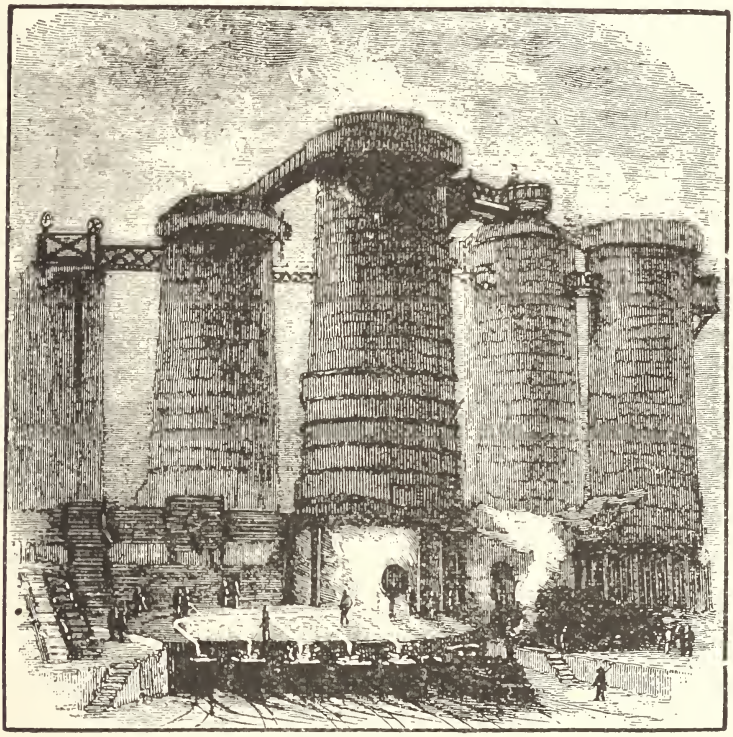
there are now but few traces of former forests. Dark blast-furnaces and puddling-furnaces have sprung up, huge and grim, in all directions ; noisy forges and collieries are to be seen every way we look ; while over all hovers thick gray smoke, proceeding from hundreds of tall buildings, and half hiding the fitful glare of flames.

We travel on until we reach the coke-making districts, where we observe a curious form of industry. Rows of hive-shaped coke-ovens are glowing on either side of us ; coal and coke fill trucks and wagons ; we crush coal-powder as we walk. The very roads about us, as well as the colliers' cottages, are black with coal-dust.

We are glad to find ourselves steaming onwards, looking at fields fresh and green, and getting a glimpse of sunshine. But it is not for long ; here we are once more plunging into another world of dense smoke, which lies gloomy and thick over the great iron center of the Union — Pittsburgh.

The barren waste, the lurid fires of the furnaces, the overhanging smoke, the begrimed appearance of the inhabitants, the railroads running into the works, with coal-laden trucks moving to and fro — these sights mark the district where iron-ore is smelted. We see numerous blast-furnaces, puddling-furnaces, rolling-mills, vast stacks of coal, of coke, and of firebricks ; we note the founderies, the

tall chimneys, and the open spaces where lie the products of mill and furnace. In adjacent parts of the country are situated coal-mines, iron-pits, limestone quarries — all things needful for smelting are found there, except perhaps firebricks.



Blast-Furnaces.

In such a place as this surely there will be no difficulty in seeing and hearing much concerning iron. There seem to be dozens of furnaces, forges, and founderies, and the air is noisy with the clang of steam-hammers at work on every side.

Our first visit will be to one of those huge circular buildings, the lower part of which consists of a solid square basement, pierced with arches. The largest of these forms the front of the furnace, and is used for the removal of the molten metal.

The furnaces, all of which are built of very hard and incombustible materials, are set in a row, so that they all can be "charged" with the different materials from a gallery which runs along the entire length. One powerful engine supplies the huge ovens with the blast of hot air which is required to keep them at the proper degree of heat.

If you could look down into one of those volcano-like openings, so full of roaring flame, you would readily understand the process of cleansing iron-ore; but as such a peep is certainly impossible, for the flames within seethe, and spout, and glare like volcanic eruptions, let me try to make the subject of iron-smelting clear from a safe distance.

Each tall and massive chimney is made of this peculiar shape, that the materials forever being flung into its gaping mouth may have room to expand before settling down at the narrowest part of the furnace.

Right at the bottom is the "hearth," which is a reservoir for receiving the metal that does not thoroughly melt until it reaches there, when, being

the heaviest of all the fusible materials, it sinks into the hearth, dropping away from all the rest, and lying in a thick, molten liquid below. Just over this hearth are iron pipes, which, in action, are bellows' nozzles, and carry into the fiery furnace the tremendous blasts of hot air produced in the engine-room. The heat is so great that these pipes have to be kept cool by means of a current of cold air, to which they are constantly exposed.

Perhaps I should have mentioned something concerning the masses of crude materials poured so liberally down into that immense, hungry-looking round chimney, seemingly ever ready for more food. They consist of roughly calcined ore, iron-stone, limestone, anthracite coal, or coke, which are thrown in, heaped up in shapeless masses, to resolve themselves presently into clear, molten metal, and cindery slag or refuse which floats on the surface.

As the upper contents of this great caldron become heated, the limestone attaches itself to the impurities of the iron, and thus forms slag; while the iron itself on its way downwards gets melted and carbonized, and becomes pig-iron.

When this mighty stew has been allowed to boil for about twelve hours, the glowing metal, now bubbling about the hearth, must be removed from the furnace — not into pots and pans, for, as

you may imagine, no such light vessels could contain such a fiery liquid. It has to be provided with a large, safe, cheap holder, in which it can settle and cool.

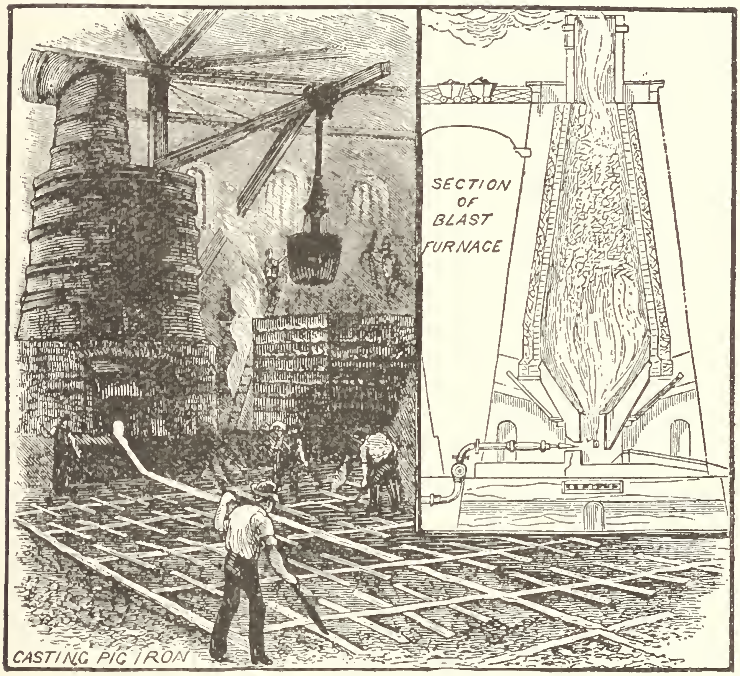
To make this proceeding possible, a very ingenious yet simple method is adopted. If you look at the space in front of the furnace, you will most likely see that it is inclosed by a large roofed shed. In there are several men busily smoothing and leveling over a great layer of damp sand, and, by means of long wooden beams, or molds, forming it into the shape of a monster gridiron, the smaller bars of which they term the "pigs."

When all is ready for the "cast," a signal is given, and one of the workmen begins to drive a long iron bar against the "hearth" of the furnace. After some determined drilling, he manages to remove a thick plaster of clay and coal-dust that has hitherto kept the liquid iron in place.

A dreadful roaring is heard, but that is caused by the hot air which is turned off during the casting. The man taps steadily, grasping his long iron rod with both hands. As the clay loosens, little dazzling spatters of red-hot metal begin to fly about it. There is a gurgling — and out gushes the liberated torrent, the spurt of which for a moment scatters the workers in every direction, but the next instant brings them all running up,

eager to hinder this too plentiful flow of iron by flinging shovelfuls of wet sand in its way.

Soon, pouring more steadily, it rushes along the main channel first, and that, being on a slight



Casting Pig-Iron.

incline, quickly fills the pigs, the small channels. As each pig-bed brims, the barriers of sand are cleared out of the way of the next one. If the metal moves too sluggishly, it is helped along by means of long poles drawn before it, leaving slight tracks which it follows.

You may imagine all this work has to be done

as rapidly as possible, for the iron stream soon begins to thicken. When a sufficient flow has been obtained, and the pig-beds have been filled, the tapping-hole is hurriedly plugged up again by means of clay and coal-dust. Wet sand is quickly shoveled over the beds of glowing metal to cool it for the sledgers.

Very soon men can be seen striding across the bars, moving here and there amid a cloud of steam, each man armed with a sledge, with which he breaks up the soft iron, separating the pigs from the large channels, and then dividing the metal into good-sized bars, which are now ready for market as pig-iron.

The men whose business it is to attend to blast-furnaces usually work in two relays, or sets; for, as a rule, their task never ceases. The mighty ovens are alight with fire and flame Sunday and Monday, and every other day from year's end to year's end, never being allowed to die out, unless it may be for needful repairs. If once allowed to cool down, a blast-furnace costs a large sum to put in proper running-order again.

As we know, a whole row of blast-furnaces are connected one with another by a continuous platform which extends along their summits, so that a few workers can easily feed them all; but they require several other attendants to get their varied

supplies ready. Thus the pay clerk tells us of keepers and chargers, slaggers, fillers, limestone-breakers, gas-stove men, laborers, and boys. All these find plenty to do.

Should you chance to see iron-smelting going on at night, you will be much struck by the strange, weird scene a forge presents at such a time,— the red glare of fire and furnace, the shadowy figures of the half-dressed workers darting here and there, seemingly at play with great lumps of molten metal; now apparently prodding them with long wands, now dragging them from one part of the yard to the other, then pushing them into the clutches of clanging black iron monsters that roll and fashion the glowing lumps of metal as easily as though they were merely pats of butter. Fire, noise, sparks, steam-driven machinery, and hurrying workmen are about you in every direction — above, may sail the quiet moon, watching the industry below.

Here are the bars of brittle pig we just now saw cast. A puddler is placing them on the floor of a puddling-furnace. If we could look inside, we should see that this furnace has a peculiar, arched roof, which causes the flames, not the gases it contains, to bend down to meet the metal placed within.

An intelligent foreman gives us an explanation

of the results of this curious baking. He says that pure iron becomes fusible by means of the various agents which are in combination with it.

In the early stage of puddling, all the carbon and silicon in the ore oxidize; then the metal, being at last free of them, is precipitated, and forms separate grains that are not quite pure — each metal granule being surrounded by a kind of film, which is a combination of sulphur and phosphorus, adhering very closely to the iron. To get rid of these minerals is the whole end and object of "puddling."

All the while that we have been listening, a puddler has been attending to the furnace, constantly watching its contents, and every now and then stirring up the metal within, by means of a long bar. He pokes and works the "charge" about through an opening in front of the furnace, taking care that every portion of the molten metal shall, in its turn, come to the surface and meet the heat. The temperature he regulates by means of a damper.

As we watch the puddler twirling the glowing red mass, our friend informs us that in one way this man is doing something very much like a washerwoman's work; for just as soapy water removes dirt, so does the constant turning of the charge remove the impurities, which come away

in the form of cinders. These impurities have to be removed before the iron can be considered good and malleable.

The poor puddler is often obliged to wipe his streaming face and arms while closely watching the metal, which, he tells us, is coming to a certain point, at which the pure iron will separate into lumps. When the charge has reached this point, he turns his rod at a great rate, collecting the grains into lumps, or balls, weighing about sixty pounds each.

The removal of these fiery balls is a most interesting sight for any one who has not witnessed it before. At a signal, the heavy iron door of the dark furnace is suddenly lifted up by means of a counterweight, while a worker, tongs in hand, pounces upon a lump of pinky metal, and swinging it onto a trolley, places it in the jaws of a ponderous hammer. This will beat it into a compact mass.

The more hammering it gets now the better for the iron, which from a formless lump, we see changing into an oblong mass, or "bloom." This is passed on to the forge rolls, consisting of two great grooved rollers, working against each other.

One end of the iron is now placed in their jaws, and as they rapidly revolve, the iron passes between them, squeezed on its way through the

groove until it comes out on the other side in the form of a rough bar. Another worker seizes this with his tongs, and passes it back to the first man, to be again rolled through in a smaller groove. Finally, the bloom takes the form of a long, flat bar. Cut into pieces, and made up into bundles, the iron is now ready for promotion.

The bundles are next carried to the "balling" furnace, where they are again heated until they arrive at welding-heat, when they must be taken out of the hot oven, pounded by a mighty steam-hammer, and again rolled through a pair of grooved rolls. This time, however, they are turned out not merely in straight bars, but varied in size and shape, according to the purposes for which they are intended.

In ship-building, for instance, "angle-bars," reminding one of the letter L, are required for making the frames which hold the outside plates. These are made of blooms that have been passed through flattening rollers, and squeezed, and rolled, and squeezed, and rolled flat again, until, in lieu of iron bars, we have immense iron sheets, or plates as they are usually termed. After having been trimmed into shape with machine shears, these plates may find places on the sides of some gigantic liner, or of some powerful man-of-war.

The pig-iron, when changed by means of this

puddling process into wrought-iron, becomes capable of bearing great strains, such as it must often undergo in certain kinds of heavy machinery, but more particularly in chains and anchors, which would be but useless things, were it not for the strength possessed by the metal of which they are composed. So important is this power to endure heavy strain, that all wrought-iron implements supplied to our Navy have to be officially tested before they are pronounced fit for use.

Strangely enough, cast-iron cannot resist stretching or twisting, but it can bear tremendous weight. The thorough understanding of this difference between wrought-iron and cast is of the greatest importance in all engineering work, as any mistake between the virtues of the two metals might cause fearful damage.

Lesson X.

Head-Work.

In the days when little work was done in cast-iron, very beautiful and artistic designs were produced from malleable iron by hammering. Continental artificers had quickly learned to beat wrought-iron into graceful curves and flourishes.

Those early artists in metal ornamented the panels of the iron doors of large public buildings, the mighty locks of castle gates, the handles of the fanciful keys of the period, and even many delicate clasps of belts intended to bear the weight of purses or pouches. Citizen, prince, and noble lady, alike delighted in the graceful articles fashioned of this trusty metal, of which many a weapon also was daintily shaped.

But, unfortunately, iron rusts, and slowly but surely passes away; so that, therefore, we have but few of those early works left to admire. We may, however, feast our eyes on a few treasures of mediæval art-work in iron — the light scrolls which Biscornette, the smith, spread as hinges on the doors of Notre Dame and of other churches, and the graceful fountain which the better-known Quentyn Matsys, the artist-blacksmith of Antwerp, left to grace the quaint old town he loved.

To us it seems strange that the ignorant populace of olden times held such skilled workers in superstitious awe. Not being able to understand how, out of a mere straight bar of iron, such beautiful objects could be made, uneducated people declared that the iron-workers wrought their designs by the aid of magic. When the clever smith, Biscornette, suddenly and mysteriously disappeared from his home and beloved forge, it

was secretly whispered that the Enemy of Mankind had claimed the artist's soul as the price of the power with which he had endowed him.

It was a peculiarity of the good old times that when any man had genius and industry beyond his fellows he was invariably accused of having obtained the assistance of the Evil One, and was in consequence avoided and held in horror by many ignorant folk, who could not understand the use he was making of the talents which the Master had given him.

Surely things must have changed for the better, as the man of genius is now reverently believed to have received his gifts from God; and if he employs them for the good of his fellows, he is sure of being respected and encouraged by all his acquaintances.

Curiously enough, the Abyssinians look with mingled respect and terror upon their skillful blacksmiths, believing that these must be aided by magic, and that they have the power of transforming themselves into monstrous hyenas that roam about the woods after nightfall to devour all whom they chance to meet.

Workers in iron are therefore avoided as much as possible, more especially as they have also the credit of causing harmless folk to become possessed by the "Buda," or evil spirit, whose ugly

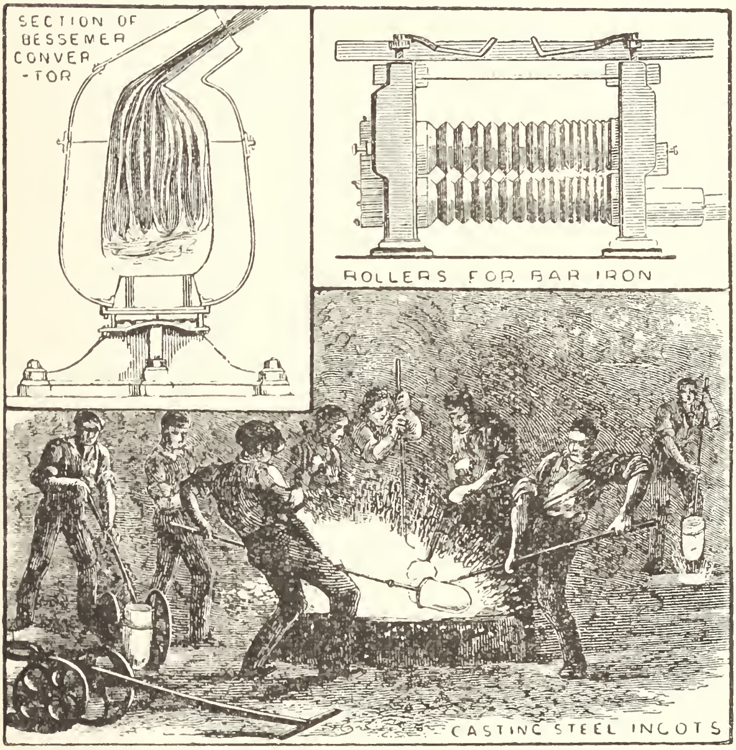
spell is worked by twisting a blade of grass into a circular form. Should the grass break, it is believed the victim dies at once; should it remain circular, he is possessed, and becomes afflicted with epilepsy — a malady which can be relieved only by the use of certain mystical charms, at the mere touch of which the "Buda" will succumb.

The victim to the iron-worker's malice insanely tries every night to escape into the woods, where the evil-minded blacksmith, in the form of a hyena, is said to be waiting to devour him. Sometimes the "Buda" will, through the lips of the person possessed, reveal the sorcerer's name. In that case the friends of the sufferer will try to capture the hyena, which they believe they can prevent from returning to his natural condition of blacksmith until he has restored their unfortunate relative to his original soundness of mind and body.

But to go back to the busy forge, noisy with the din of iron-workers and the clang of steam-hammers.

Let us cross the yard, and watch the various processes going on in that large, half-open shed, where iron is being rolled into sheets. The first step we take on entering tells us we are treading on a floor neither of wood nor of stone, but of metal, bright with much rubbing by many feet.

In every direction are rollers and great revolving wheels. Yonder is a pair of monster shears, whose steel jaws are opening and shutting in a hungry fashion, that somehow makes us shudder



Making Steel.

with the notion that it would bite off a head quite easily, and, like some monster of early fable, rather enjoy the biting.

Here we find another great fiery furnace, which one man is keeping open while a second sturdy

worker is dragging a lump of glowing metal out of the flaming recesses. As he swings it forth, clinched fast at the end of his long tongs, we cannot help noticing that it is very like one of those big bars that we last saw being pounded by the "shingling" hammer.

He turns and twists the heavy red mass, until, by what seems to be some sleight of hand, he has pushed one end of it between two ridges in the rollers. These consist of a graded series of grooves, each one so shaped as to narrow the space between which the metal must presently pass. Once in this heavy machine, the bar gets such a squeeze that it rolls out much flatter and thinner than it was when it entered.

It has a curve upwards now, of which curve the worker takes advantage, for by it he coaxes the bar to re-enter the rolls. In it goes, and out it comes again, each time getting more and more flattened, until, after perhaps half-a-dozen journeys in and out, the solid bar has changed into a long strip of bright-red metal. This strip is now hurriedly seized upon, and carried off to those ever-opening shears, that with two motions will clip off the rough ends, and with another closing of its blades will cut the strip in two as easily as though it were a sheet of cardboard.

As the halves of our thin bar come apart, they

are carried off to another machine with long, smooth rollers, that eagerly seize upon one end of the metal presented to them, and roll as the bars constantly travel backwards and forwards. These are steadily getting thinner and longer; for the space between the rollers has been narrowed and narrowed, and still the metal is forced to squeeze through, until at last the bars are transformed into flat sheets or plates.

There is here a smaller tower which the workers often refer to as the "cupola furnace." It looks very much like a blast-furnace; but we shall find, on inquiry, that it is used to melt only iron that has been already smelted. It is by means of cupola furnaces, built of firebricks and lined with iron, that castings in iron are taken — a very curious process, which we will stay to witness.

We notice that the furnace is supplied with air by a fast-revolving fanner, which produces a cold instead of a hot blast.

We note, also, that the floor is covered with the very finest sand, which, however, looks so black and grimy that we can hardly guess what it is. All about us we see the cast-iron "boxes" in which the castings are to be made; they are of every variety of shape and size, but each box is cut in halves, an upper and a lower half, crossed with thin plates to hinder the sand

from falling out, if a half-box should be accidentally tumbled around.

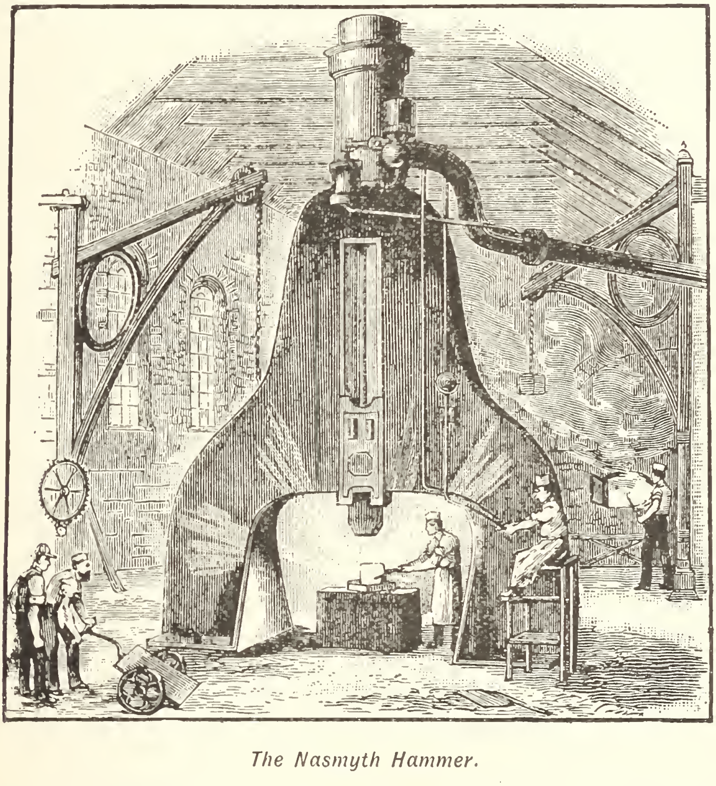
Here is a man about to cast a number of small cylinders, all alike, of which he has the wooden model at hand. He first proceeds to fill the lower half of a box with the sand, which lies in plenty under his feet; then he lays the model in the sand in such a manner that its lower half is embedded tightly and evenly; next he replaces the top half on the box, and fastens it down securely by means of bolts or pins.

More soft sand is now poured in at the open top, and is packed tightly until the impression of the upper uncovered half of the model has been taken; then the box is opened, and the model is lifted out of its bed, leaving exact molds of the upper and lower halves on those two half-layers or sand-patterns. Pressure has fixed these molds so firmly in shape that the molder is able to touch them up into perfect form wherever the sand seems not to have fitted quite neatly. He shakes powdered charcoal over the sand-pattern before taking his cast.

This operation he performs by again fastening the two portions of the box together, this time with no solid model in them, and pouring the molten metal in through a channel left for the purpose. When cold he opens the box, and turns

out a completed solid object of the exact shape we just now saw hollowed in the sand.

We have seen the casting of small objects only; the casting of larger things is a much more difficult and elaborate process. A large iron gate, for



The Nasmyth Hammer.

instance, would be cast in a mold constructed of brick. Sand or loam is used in brick molds to take the pattern. This is stamped on by a heavy wooden frame, made the shape of the casting required.

As we linger to watch the men standing in the red glare cast by the mass of glowing iron they are placing under a steam-hammer, we are reminded of Nasmyth, the patentee of the first huge implement of this kind. Nasmyth's hammer has given an impetus to the manufacture of iron, and has afforded facilities for the welding of large blocks of malleable iron that could not be welded by the tilt and helve hammers. We have only to instance the forging of the stern-posts and cut-waters of iron ships, and screw-shafts of ocean steamers to indicate the value of the steam-hammer.

When Nasymth was but a lad, the youngest of a family of ten children, nothing delighted him more than to spend his half-holidays and spare moments in a neighboring forge that belonged to the father of one of his schoolfellows.

The boy did not go wandering aimlessly here and there. He spent his time watching the different processes through which the metal passed, learning the details of the molding, casting, forging, and smithing work going on about him.

When, after years of hard work and self-denial, he became exceedingly wealthy, he often declared that the time spent in the different small shops connected with that foundery was the true apprenticeship of his life. No bad apprenticeship either

for such a clever, industrious lad, "with eyes," and determined to understand as well as to see.

Not only is Nasmyth's mighty steam-hammer worth watching, but some of his words are worth remembering; for instance, when addressing young workers, he said: —

"If I were to try to compress into one sentence the whole of the experience I have gained during an active and successful life, and offer it to young men as a rule and certain receipt for success in any station, it would be comprised in these words — 'Duty *first*, pleasure *second*.' From what I have seen of young men and their after-progress, I am satisfied that what is generally termed 'bad fortune,' 'ill-luck,' and 'misfortune,' is, in nine cases out of ten, simply the result of inverting the above maxim. Such experience as I have had convinces me that absence of success arises in the great majority of cases from want of self-denial and want of common-sense, the worst of all maxims being, 'Pleasure first, work and duty second.'" Good advice, and well worth consideration surely.

Lesson XI.

In Other Lands.

Perhaps the places where we should least expect to find iron are the beds of lakes; yet lake-ores exist in great profusion in Sweden, where "water-mining" keeps many people busily employed in certain seasons of the year. There is the hard and heavy "pearl" ore, which has to be raked up from muddy depths; the "money" ore, so called from its fancied resemblance to coin (but this ore is not of very good quality); the greenish "gunpowder," lying in close, heavy grains among the sands from which it seems loath to separate; and the "burr," thought to resemble the head of the wild burdock flower.

All these ores usually lie spread in layers of from twelve to two hundred yards long, but never so situated as to meet a strong current; and, strangely enough, the ores vary according to their positions in a lake. Thus at the head of the lake "gunpowder" may be met with; then "pearl," "money," and "cake" will be turned up by the industrious explorer.

Could he succeed in carrying all the ore away with him, he would not exhaust the wonderful

mine. In time it will once more be rich with just such another store of this treasure among minerals. In the short and pleasant summer-time a great deal of ore is dragged up from the depths by dredgers in boats. When winter touches the waters with its icy hand, workers prospect for the iron-ore by making small holes in the ice, and then feeling about beneath it by means of a long and slender pole until they are certain that they are in a promising place.

Two men are usually associated in this search, and when they have thus found a likely spot they mark out a certain boundary about it by sticking twigs in the ice. They thus gain a legal right to work in that place during the winter.

As soon as the ice is safe enough for their purpose, our partners take possession of their "claim," as a miner would say, and set to work in earnest by first making an opening of about a yard square, and through this aperture letting down a kind of iron sieve which is fixed fast to a long rod. Then having collected all the ore they can drag and scrape together by the aid of a long rake, they pull it onto the sieve, which is then drawn up, with its wet contents — mingled ore, mud, sand, and clay.

To cleanse this mass somewhat, it is put on another sieve, which is lowered a very little way into the water, where it is shaken about until a

great deal of the rubbish which came up is washed away, and the ore is left comparatively clean. You may think that this mode of mining is a slow way to get iron-ore. Yet it is said that, when they are working a good claim, two strong men can collect sometimes as much as a ton and a half of ore in a day, and that 22,000 tons of bog and lake ores are thus collected in Sweden every year.

But iron-ore is usually found hidden away underground, and not under water. When found, it presents but a dark, unpromising outside. In this state it is known as "ironstone," and its quality varies according to the country and district in which it has been mined.

Sometimes this "stone" contains clay, but no lime; sometimes lime, but no clay; but all varieties of iron-ore contain water. Flint, sulphur, and carbonic acid are almost sure to be present in ironstone. This is usually discovered in beds varying in thickness, and differing very much in position; for sometimes they come cropping out of the earth's surface, more often they are found far below it.

Among the finest kinds of iron is magnetite, or magnetic iron-ore, which comes from the mines of Dannemora, in Sweden. This ore is smelted with charcoal, and is used to make the best steel knives, razors, and surgical instruments.

There may be several beds or seams of iron-ore

lying one below another, but the merits of each are well known to the miners, who speak of it by a distinctive name. These beds of ore are often separated from one another by masses of different minerals. When the ironstone has been blasted or loosened by means of gunpowder, it is brought up to the surface of the earth, piled on trolleys, and carried away to be "roasted." Roasting used to be done by burning the stone in the open air, but now the iron-ore is generally dropped at once into the blast-furnace.

Perhaps the question here suggests itself, "Why does smelting remove the impurities which are always mixed up with iron-ore?" Chemistry tell us that these impurities are separated through "affinity," or a tendency certain things have to combine with one another. Thus the lime and clay contained in this rough ore have a greater liking or affinity for each other than for the iron they are mingled with; therefore, if the ore be of the clayey kind, the smelter adds a certain proportion of limestone to it; but, if the ore be a calcareous or limy sort, he adds clay as a flux, or filter, to help to extract the iron from the raw ore.

When timber was plentiful, and the uses of coal were almost unknown in America, such ores were, of course, always smelted with charcoal. Nothing could be better, so far as the quality of the metal

produced was concerned; but in these busy times our trade in iron and steel would come to a standstill were it not for the coal and the coke that aid our iron-workers to get through their tasks rapidly.

To see the great change that has taken place in this wide-spread industry of iron-working, let us go back to those good old times. Three centuries ago the midland part of England was a little-visited but pleasant wilderness. In its woodland recesses hid deer, while here and there was a hamlet or village where dwelled a few families, the men being wood-cutters or weavers mostly.

If we visit the English midland counties to-day, we shall find that they form the center of a hive of industry; yet in the densest and dingiest of the busy districts we shall meet with the bare, gray ruins of many an ancestral hall. In those old days, the Dudleys, an aristocratic family, had here extensive domains, pleasant woodlands, musical with the songs of birds. Now the neighborhood is noisy with the clang and rattle of machinery, and dark with the smoke of gloomy furnaces — true signs of the change in times.

Yet in the days when the lords were powerful, and the neighborhood was lovely, all was not so pleasant in the fair midland counties. There was too often feud or violence among the barons.

Thus, we hear of one bold Dudley starting off on

a dark night, at the head of a hundred and forty vassals and followers, armed with forest-bills, long staves, and bows, to rob their unsuspecting neighbors. No doubt there was fine feasting on the return of the venturous company, and many a sheep and joint of beef were cooked on those huge hearthstones which we now survey with wonderment.

What grand old times those must have been for all persons not able to keep their own from stronger hands! I much prefer a later period, when the lords of Dudley lived more peaceful lives, and obtained steadier revenues from the iron-mines lying in every direction, and yielding, annually, millions of tons of ore.

At last a great danger began to threaten the prosperity of the owners of the mines. The ores had of course to be roasted and smelted before they could yield iron; and wood, the only fuel then known, was yearly becoming more expensive.

Districts lately luxuriant with every kind of timber were assuming a bare and desolate appearance, and it seemed probable that the flames of those craving, ever-hungry furnaces would some day have to be allowed to die out for lack of fuel. Once extinguished, who could say whether they would ever be relighted? What use or profit could possibly be made of the abundant ore, which

gave employment to many, and constituted the treasure of its owners?

About this time the lord of this rich domain had a kinsman known as Dud Dudley — a man "with eyes" evidently, for it appears that he was among the first who, considering what remedy might be applied, was struck with the idea of utilizing in some way the despised coal that lay in rich abundance under his feet.

He at length proceeded to test this new fuel in the furnaces which had hitherto been fed only with charcoal; but, as he did not understand the right way to burn coal, and as the furnaces were not properly adapted for its use, the ore refused to melt, and the coal proved a failure.

Dud Dudley, persuaded that his idea was a good one, spent over forty years of his life in attempting to realize it. He was an unfortunate man, and never lived to see the success of his great discovery. Folks treated him as though he was more mad than sane for trying to smelt iron with coal. His experiments were mocked at and opposed, especially by the master charcoal-makers, who dreaded lest their hitherto flourishing trade should be ruined. Then, too, he became involved in the great civil wars of the period, and for a long time was harassed by many political enemies.

Finally, when he recommenced his smelting

experiments, he obtained but very poor results. The furnaces he constructed being much too small for his purpose, the crude sulphur contained in the coal was brought into direct contact with the ore, and this sulphur so injured the iron it fused as to render it of little use.

Wise men declared that nothing but wood-charcoal could smelt iron-ore properly. But when charcoal could no longer be obtained in anything like the necessary quantity, the production of English iron grew less and less. Thousands of pounds then had to be spent in purchasing iron of the Swedes, whose preparation of this ore has always been unrivaled.

Yet Dud Dudley had set the ball rolling, though he had failed in producing the desired result. Others learned the lesson his failure taught. The plan of smelting iron-ore with coal was tried first by one, then by another, and the final outcome was the success of the famous iron-works at Coalbrookdale.

It was a lovely place surrounded with luxuriant timber-trees, when Abraham Darby, an iron-worker, seeing the ruin threatening English trade, determined if possible to work out that problem which had cost poor Dudley so much time and money and trouble, although he had worked in a district particularly suited for his purpose; for in

it there was to be found every necessary — iron-ore, coal, the limestone for flux, and even the fire-clay required for the construction of the brickwork of the kind of furnaces he should have built. This clay is now employed all over the kingdom for making "pots" in glass-houses and crucibles for cast-steel.

Darby had, no doubt, the great advantage of going on where his unlucky predecessor left off; at any rate, he at length read the riddle, and managed at last to smelt ores properly with coal. This new fuel also soon enabled steam-power to blow the fires with its mighty breath, and to lend that aid which was to make the British iron-trade of great importance.

Then another wonderful stride in advance was made when in 1826 a clever Lancashire worker converted pig or rough cast-iron quickly into good malleable, or wrought bar-iron. Hitherto such conversion had been such a slow process that only ten tons could be turned out weekly where, thirty years later, by means of Henry Cort's inventions and improvements, 10,000 tons were produced annually.

Next came the same clever man's great invention of "puddling," that curious process we saw carried out in the furnace. It is easy to understand that in this operation, as the pig-iron, what-

ever may be its quality, comes out workable and well-grained, the great advantage of the process lies in the fact that inferior iron-ores can be profitably worked, though they contain phosphorus, sulphur, and other substances that cannot be completely burned out of them in the furnace.

Lesson XII.

A Grand Discovery.

It seems as though all inventors must have learned to ignore the word "impossibility." The grandest inventions would have been nipped in the bud had those gifted men accepted "impossible" as a conclusive verdict — a verdict given offhand by all those persons who found it easy to settle a difficult matter by using a big word. And yet we can scarcely wonder at the incredulity of the iron-smelters, when one among them stood forth, and gravely proposed to convert pig-iron into malleable metal, and to work this transformation not only in a few hours, but also without the expensive aid of additional coal.

This change did seem really impossible; for all the heat of the iron-workers' many furnaces had as yet succeeded only in rendering the said pig soft

enough to bear hammering into shape. Here I must explain that iron comes from the blast-furnace in a highly carbonized and impure state.

Refining is effected by the singular puddling process, decarbonization being caused by the exposure of the heated metal to the air. For the oxygen in the air, the carbon has a great affinity.

This fact has often been demonstrated by the simple experiment of tying a large nail to a string, heating the nail-tip until it is white-hot, and then whirling the nail rapidly around by means of the string. As the nail flies around, its glowing end burns and brightens, scattering a circle of sparks, which show that combustion is taking place rapidly. We can see oxygen increasing combustion, if we watch the blacksmith at work at his forge. He forces air down on the coal in his fire, thus producing greater heat.

Sir Henry Bessemer's idea was simply to use air for removing the carbon and increasing the temperature. He proposed to convert pig into malleable iron, "by forcing into and among the particles of a mass of molten iron currents of air." Here you have his plan in his own words, which I think even the youngest in the class can understand.

The great difficulty for a long time was to learn how far this process of decarbonization should be

carried. Many experiments failed ; at last, when success was attained, the Bessemer process proved to be of the greatest value. By means of it a sort of steel suitable for various purposes can be made at one-fourth the cost of cast-steel, and the converted metal is far more durable than ordinary iron.

Come with me to a Pittsburg steel-works, and let us see with our own eyes how Bessemer steel is produced.

As we enter the extensive workshop, we are bewildered by strange sights and sounds. Men are working in large circular pits sunk deep in the ground. About these openings are placed a number of iron molds, which are lined with infusible clay, to prevent them from being destroyed, when the seething contents of the "converters" are poured into them.

These converters, of which there are two to every pit, above which they are raised, are large oval vessels, which can be swung about. Until of late, they were, when steel was to be made in them, filled with a mixture of molten pig and "spiegeleisen," a Swedish metal, prepared for them in cupola furnaces ; but now the iron comes directly from the blast-furnace, where it has been fused.

To receive the flow of melted iron, the con-

verter is tilted at a certain angle; when the molten supply stops, the huge cannon-like utensil is swung up again into a horizontal position, and the converting, or blowing, begins, noisily enough. For now a tremendous blast of air is forced up into the seething contents of the vessel through openings in it — such a gust of wind as only a set of engines representing the united strength of 5,000 horses can produce. The result is truly wonderful.

But I must quote Mr. Bessemer's own description of this strange cookery: "When the process is brought into full activity, small though powerful jets of air spring upwards through the fluid mass. The air, expanding in volume, divides itself into globules, or bursts violently upwards, carrying with it several hundredweights of fluid metal, which again fall into the boiling mass below.

"Every part of the apparatus trembles under the violent agitation thus produced; a roaring flame rushes from the mouth of the vessel, and, as the process advances, changes its violet color to orange, and finally to a luminous white flame. The sparks, which at first were large, like those of ordinary foundery iron, change to small hissing points, and these gradually give way to specks of bluish light, as the state of malleable iron is approached."

A weird sight, before which fireworks would fade into insignificance! After this mighty blowing has been going on for some time, the "spiegeleisen" is added to the molten iron, and the whole is mixed and combined thoroughly by means of the strong blast.

When at length "converted" enough, the liquid is poured into monster ladles, which in turn drop it into molds, where it soon cools into solid ingots of cast-steel. These ingots are wheeled off to be reheated in a gas-oven. After being thus heated, they are delivered over to the tender mercies of monster steam-hammers; or, perhaps, they are squeezed in the rail-mills, from which, after many struggles, the flat, solid blocks of white-hot metal emerge long and thin bars ready for use.

Those square buildings yonder contain the wonderful engines which produce the blast for the converters. Beyond are the boilers which supply the engines with steam. These boilers are heated — not with fuel, but with the various gases produced by the fusion of the different materials which are being constantly poured into the blast-furnaces.

The gases pass to the boilers by means of pipes, and, being intensely hot, change the water into steam very rapidly and cheaply. In all such large works as these, economy is studied in every detail.

Now for a short talk concerning steel, which, as we know, is merely iron treated with carbon in a peculiar way. Steel is much tougher, and possesses a far greater degree of elasticity than iron.

Properly tempered, steel can be bent almost double. Its flexibility makes it invaluable to the steel-pen maker, who uses thousands of thin steel plates, which he cuts into narrow strips and stamps into shape. The "hair-spring" of a watch affords the best illustration of the value that *can* be given to a small piece of steel by manual labor. 4,000 watch hair-springs, though weighing scarcely more than an ounce, may cost $2,000.

Wonderfully small and ingenious articles have been constructed from this metal. For instance, we read of a tiny padlock made a hundred years ago by one James Lee, which, with its key, did not weigh as much as a dime. In the Centennial Exhibition there was shown a lock only $\frac{3}{32}$ of an inch in thickness, the work of two clever boys.

If we ask what steel is, even wise folks seem somewhat puzzled to explain. They tell us that it is a combination of iron and carbon; but so is cast-iron, and so is wrought-iron even. Steel, however, has qualities peculiarly its own. A variety of it is made from bar-iron by "cementation." This process was first heard of in England

about the middle of the last century, and it soon effected a total revolution in the cutlery trade.

Bar-iron intended for first-class cutlery steel is of the best brand. The prepared bars are taken to an odd-looking conical building called a "converting furnace," in the floor of which there are two openings shaped like shallow ovens. Flames beat all about them, and keep the contents at a high heat.

On the bottom of each of these trough-like ovens is first scattered a layer of powdered charcoal. Upon this layer is placed a row of the short iron bars which are to be transformed into steel.

On these bars another layer of charcoal is scattered; then more iron, more charcoal, until the trough is full. The top of this pile of iron and charcoal is next plastered over with a kind of cement, to prevent the charcoal from burning away. A fire is now lighted, and the whole pile is kept in a red-hot state for some days. During this time the baking is carefully superintended by an experienced worker, who every now and then draws out a test bar, from the appearance of which he can judge of the exact progress of the rest.

This progress he has to watch very closely, as steel for different purposes requires a different amount of conversion. For instance, steel in-

tended for cutlery does not need to be "treated" quite as much as steel to be used for fine files.

At the required point the fierce fires are stopped, and the ovens are allowed to cool slowly. When they are opened, and the bars are taken out, these will be found to be covered with blisters. The bars have absorbed a small quantity of carbon, and are no longer iron, but "blister-steel;" and as at its first stage blister-steel is not considered fit for manufacturing purposes, it has generally to go through other operations, known as shearing, double shearing, and casting. This last process is the one to which we owe the excellence of modern steel.

Blister-steel, broken into bits, is first put into crucibles, or melting-pots, which must be composed of very hard material, as they will have to bear intense heat. They are placed in a kind of furnace which is sunk in the floor of the stone-paved casting-house, and are kept closely covered with an iron lid. This is lifted off from time to time that the worker may glance at the contents of the furnace, or may add more fuel.

This man must be very skilled at the work, for he will have to judge by appearances, unaided by any test, as to which is exactly the right moment for adding the mixture of carbon and manganese required to refine the steel. He gives a signal

for removing the pot as soon as certain signs appear in the glowing steel.

While the metal stew is getting ready, the worker places his cast-iron molds in position for its reception. These are not unlike long bullet-molds, being composed of halves, which are bound closely together. Their insides are coated with a fire-proof composition.

When the signal is given, the lid is lifted off the furnace, the fuel is pushed back from a white-hot crucible below, which a masked man then seizes with a pair of pinchers, and drags out of its fiery resting-place. Poor fellow! it is fearfully trying work, for he has to face the terrible heat beneath him. Then the lid has to be lifted off the crucible, and the liquid steel, upon which float little greenish sparks, is "teemed" or poured straight down into a mold — an operation which requires great care.

The vessel is now to be filled again with bits of steel, and to be returned to the furnace. When the casting is cool enough to bear removal, the halves of the mold are unfastened, and their contents are turned out, and prepared for the steam-hammer.

Manganese is a mineral that is worth briefly sketching. 50,000 tons of it are used every year in the United States. We find its different

oxides employed in potteries. It gives a black color to certain kinds of opaque china and to tiles; it helps to clear flint-glass of impurities, and to tint it a beautiful purple. Manganese is employed in paper-making, in dyeing cotton, and in making bleaching-powder. As we have seen, manganese is also of value in the conversion of iron into steel by the Bessemer process.

It is thought that the celebrated Toledo blades of the Middle Ages owed their pliability and excellence to manganese. Surely it is worth inquiring where such a useful thing is found.

Large supplies of this mineral are obtained from France, and from the mountains of Spain and Portugal. The miners find it in detached lumps and masses, which they collect and pack in panniers, which are then loaded on mules. These animals are led down to the nearest streams, where their loads are closely examined, carefully sorted, and washed.

The best pieces are again repacked in the baskets, and the plodding, sure-footed animals are led off, sometimes many a mile over very rough roads, to the nearest seaport town or railroad-station. Virginia has the largest manganese mine in this country.

Let us now take a flight over the sea, away to Essen, a quiet town of Rhenish Prussia, where

we shall find a very crowded hive, swarming with busy metal-workers of the most ingenious kind. In that city there is an immense establishment where not only almost all the German artillery guns, their carriages, and projectiles are made, but there also are made many articles required for more peaceful needs and interests, — shafts, boiler and ship plates, axles, tires, wheels, springs, and steam-engines.

Here we are at Herr Krupp's famous works, where there are usually more than 1,000 furnaces blazing, not to mention hundreds of smiths' forges and steam-boilers, to keep all of which going, we are told, it takes more than 600,000 tons of coal and coke a year. The work-buildings cover 200 acres, and are lighted by the electric light. Locomotives are flying about the works, and rail-tracks are running in all directions. Here are telegraph stations, from which we may send messages on lightning wings to almost all parts of the world; here is a chemical laboratory as well as a photographic and a printing department — all extremely useful conveniences in these monster works, where 12,000 men are employed.

In fact, the whole place represents an industrial town, for near the forges are to be seen sundry model villages — "Krupp colonies" — where the workmen and their families are comfortably and

cheaply housed; where the employees can send their children to schools in every way suitable for them; and where there are several provision stores, flour-mills, bakeries, and other establishments at which food-materials may be bought at cost prices. Altogether it is a most interesting place to visit.

The Essen Factory offers a marvelous spectacle in the exhibition of its Bessemer process in full operation. Rivulets of fire and roaring jets of flame, mingling with myriads of star-formed sparks, constitute a display which might suggest actual peril to the beholder, were it not for the evidence of perfect control which is being exercised over these fiery forces.

Bessemer steel, I may remark, is not used in making Krupp guns, but it is largely employed for various other purposes, especially for producing steel rails. In the Krupp works the metal is never allowed to become cool, from the time the ore is first melted, until the rail is made.

The rollers employed in the Krupp mills are wonderful specimens of mechanism, and their operation is a remarkable triumph of genius and skill. Recently a new rolling-mill has been added, which, it is stated, is not surpassed by any in the world. It is for rolling armor-plates, and it turns out the heaviest plates of this description that can

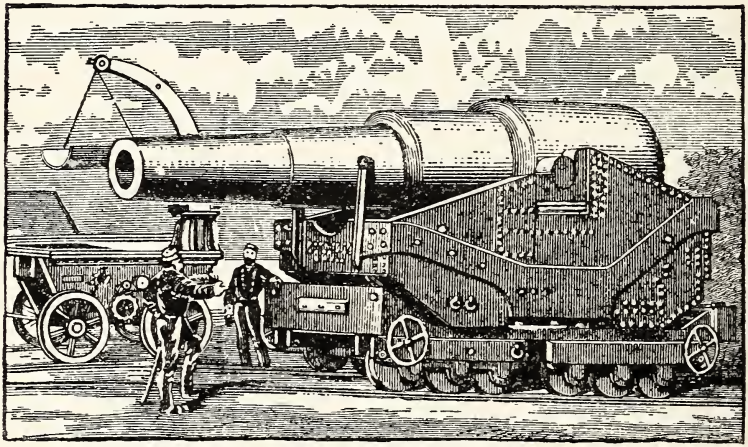
possibly be required; that is, those about 28 inches thick and nearly four yards wide.

Some idea of the great size of its machines may be obtained from the statement that each pair of crucible rollers, when in the rough state, weighed 100,000 pounds. Immense shears with long steel blades cut the plates as easily as ordinary shears cut paper. Automatic apparatus is employed for raising and lowering the plates in their passage from one set of rollers to the other, and for guiding them as they pass between the rollers or are taken from them. So automatic is this process that, without the aid of tongs or levers, the glowing blocks move back and forth between the rollers. Plates for ironclads are thus made apparently without the help of human hands.

The forging of a solid cylinder of steel under the 50-ton steam-hammer is one of the marvels that we are privileged to see. The mass of metal is, we learn, intended to form the tube or interior of a 35½-centimeter gun, equal to a bore of 14 inches. The weight of the steel mass is about 30 tons, and its length is 30 feet. It is rapidly hauled out of the furnace in a state of incandescence, and is pounded under the giant hammer — the largest in the works.

This hammer was set up several years ago, and has been at work, more or less, day and night ever

since, never having required any repairs, except some of a trifling character. The ingot now subject to its power is beautifully controlled by means of chains connected with a steam-engine, so that it is turned round under the hammer without any visible intervention of the workmen.



110-ton Gun.

This hammer, we are told, is able to give a stroke due to a fall of 12 feet, and the force of the blow is considered equal to 1,000 tons.

Passing on to another building, we enter a "finishing-shop," where the final touches are given to the curiously shaped masses of metal. Here are lathes, and slotting and planing machines, whose powerful chisels no metal can resist. Iron and steel are cut as easily as if they were wood. We note the extreme clearness of the steel which in

some cases resembles polished silver. A single speck in a block of steel is held fatal at Essen, and such a product is at once rejected. One large building contains guns packed up ready for their departure for future battle-fields.

Great 12-inch guns are scattered about as if they were ordinary commodities, and, on emerging into the open air, a field-gun is seen traveling aloft on a wire-rope railroad. By means of this aerial line, light guns are transferred from one building to another on the level of the upper floors.

And now let us turn to something that saves instead of destroying life. Let us give honorable mention to the sturdy and patient anchor-smiths. The regular "bing, bang, bing!" of their hammers we hear afar off as these fall on a red-hot mass of iron that is soon to be transformed into a mighty

> "Anchor whose giant hand
> Will reach down and grapple with the land,
> And immovable and fast
> Hold the great ship against the roaring blast."

Only the very best scrap iron is used for making the "giant hand," and the chains which are to be found on board every vessel. The scrap iron is first beaten into big slabs. These are shaped by a heavy drop-hammer, and are finished by hand—no slight work when the anchors are to be large

ones. The anchor made specially for the Great Eastern weighed 8 tons.

At best, anchor-forging is a hard and trying task, as the smith must rush up to the great glaring mass of red-hot metal, and strike swiftly and surely, before it has time to cool; but the heat is so intense, and his sledge-hammer is so heavy, that the poor fellow can let it fall but once, and must then hastily retreat amid a shower of sparks, and make room for his fellows. These rush forward, each one in his turn, their successive blows causing that regular ringing which at first pleased our ears, but which threatens to deafen us now.

All anchors for our naval vessels must be thoroughly tested by hydraulic power used by properly appointed persons. After carefully examining the different parts of each anchor, those experts will, if the anchor passes their examination, give it their official stamp declaring it a piece of workmanship as good as strong arms can fashion.

Lesson XIII.

Pins and Needles.

If a boy wishes to express the worthlessness of an object, does he not sometimes say, "I would not give a pin for it"? Yet there are complicated machines invented for the sole purpose of making pins. Commercial statistics prove that Great Britain produces about fifty million pins *daily!* British trade in these trifles is estimated to reach $2,000,000 a year.

When metal pins first came into use in England, — and their use began about the commencement of the sixteenth century, — they were brought to that country by foreign traders, and were expensive, and a gross of them formed an acceptable New Year's gift. But as they were not always obtainable, a sum of money wherewith to purchase them was sometimes more conveniently presented as "pin-money" to ladies expecting some pins.

There were so many complaints concerning these first pins that, in 1543, Parliament passed an "Acte for the trewe makinge of pynnes," wherein it was decreed that they were not to be sold per thousand for more than six shillings and

eightpence (an amount representing then about ten times the value of that sum now).

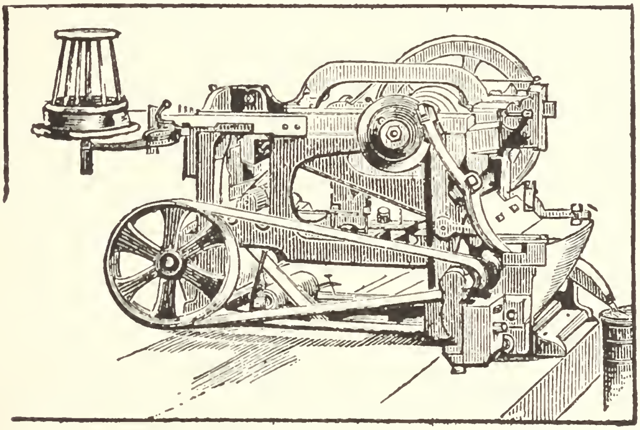
The change from the old-fashioned clumsy bone and wooden skewers to iron-wire pins must certainly have been such a very agreeable change, that we can scarcely wonder that the ladies were at first somewhat extravagant in their purchases of good pins. During the early part of the reign of Queen Elizabeth, it is said that £60,000 were annually paid for imported pins. But before the end of her Majesty's reign plenty of English "pynners" were found, whose fine work in metal "pynnes" excelled any similar foreign work.

Brass pins are said to be a French or an Italian invention. English "pynners" were regularly at work by 1542, as it is on record that they were forbidden by Act of Parliament to sell "any sorte of pynne except suche as shall be double-headed and have the pynne soldered faste to the shanke of the pynne,"—a law which reads very much as if fault had been found with their wares.

But let us come back to our own times and call on our own pin-makers. First, let me remark that there are "pins *and* pins," from the doll pin to the sturdy blanket pin as long as your finger. There are the "short whites" and "mixed," for ordinary use; there are long, fine wire pins, employed by naturalists for transfixing insects; and there are

doubled-up safety pins. It is interesting to learn that safety-pins were made originally in imitation of the long thorns which wandering gypsy women ingeniously doubled and twisted to hold their tattered shawls together.

There are long hat-pins, ornamental hair-pins, mourning-pins, and other kinds of pins, whose



Pin-Making Machine.

names I do not remember just now. Millions of pins are made in France, Germany, and Austria. In our own country, 700 tons' weight of these humble articles are annually turned out, most of them to vanish nobody knows where. We scarcely need be told that to make all those pins a large quantity of metal is necessary.

Then there must be a great supply of cardboard absorbed in the thousands of dozens of boxes in

which mourning and hair-pins are usually sold. It is easy to believe that the pin industry must be of importance, and that the little machine which can make pins at the rate of *millions* a day must be worthy of notice in our world of useful things.

Perhaps we shall admire the pin-machine, an American invention, all the more, if we hear a manufacturer familiar with the pin-making of sixty years ago describe how the pins then, perhaps, used by our grandmothers were made.

He says, "One man draws out the wire, another straightens it, a third cuts it, a fourth points it, a fifth grinds it at the top for receiving the head. To make this head requires three operations. To put it on is a special occupation, to whiten the pins is another. It is a trade to put them into paper. The important business of making a pin is in this manner divided into eighteen distinct operations, all performed by distinct hands."

To-day wire is transformed into pins at such a rate that it is impossible to count these as they fall, or to tell with certainty what becomes of the wire during the short interval which elapses while it passes off the reel on which it is wound.

We can watch the curved wire while it is being drawn out and straightened, as it travels on to be cut; then we see that a pin's length of it is held fast by a kind of nipper, while an iron ham-

mer drops sharply down, and gives this pin-length of wire a neat little head, — a head that will hold on, unlike those pin-heads labored over by the worthy "pynners" of old.

The bit of wire — we cannot call it anything else yet, though it is provided with a head — is now snipped off its parent coil, and away it slides down an incline into a kind of box, where its shank will slip into a small slit in an iron plate. Herein, the prisoned bit of brass wire must hang helplessly by its head.

As the future pin dangles here, in company with many others of its kind, the blunt ends of all of them are sharpened by a revolving steel roller set with file-like teeth of various sizes. As this roller flies round, it encounters the wires, and changes their blunt ends into fine points in far shorter time than I have taken to describe this most ingenious process.

As each pin is pointed, it is instantly pushed forwards by others that want attending to, and that come rushing on at the rate of a half-dozen a second. Each pin, after being ground, falls into a large box which stands under the pointing roller at the end of the machine. Out of this box we pick, each one of us, a newly made pin, and we note with admiration how neat and thorough is the workmanship of the pin-machine.

Yet, though they have been just made, they do not look quite like the bright, silvery pins we buy. They are not yet cleaned nor colored ; the machine merely shapes them.

They require whitening now; and to see the whitening process we must step into yonder room, where a peculiar kind of cookery seems to be going on. Here innumerable pins are undergoing boiling, in order to remove dirt and grease from them. Next, they are laid in a large copper vessel partly filled with alternate layers of pure grain-tin and of pins.

When layers enough have been arranged one upon another, they are covered with water in which cream of tartar has been dissolved. Then the immense kettle is gradually heated. In a short time we see a change coming over its contents ; for the acid, acting upon the tin, produces a solution of tin which "silvers" the pins, giving them that new look we missed just now.

When they have arrived at the proper degree of luster, they are washed in water, are dried, and then are further brightened in bags filled with bran. The pins are next collected in boxes, and are carried off to the papering-room to be fitted into cases, or to be ranged side by side in rows on sheets of colored paper.

This last operation once employed many chil-

dren's fingers, but it is now the work of another wonderful little machine. This iron pin-arranger, which also was invented in the United States, requires the assistance of only one girl, who feeds it with as many pins as are to be "folded" for sale. All she has to do is to drop the pins into a hopper, which passes them on to a steel plate with as many slits in it as there are to be pins in a row.

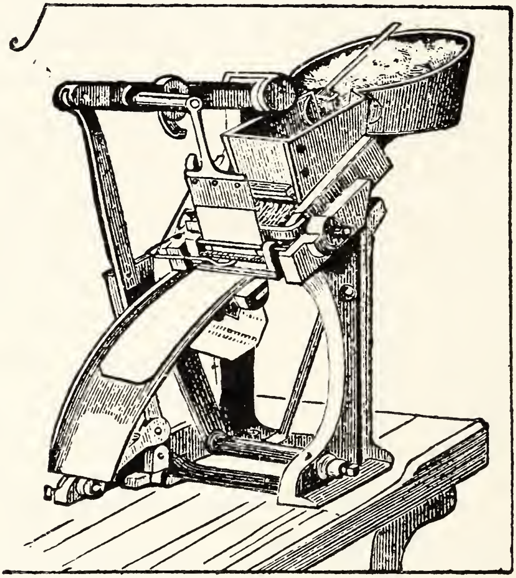
The girl next proceeds to stir the contents of the hopper with an article that looks very like a comb, and the pins drop into the slits in the plate, and hang by their heads, as they hung when they were being pointed in the first machine. Then the paper is neatly folded and crimped, and is thus presented to the lines of sharp, protruding points.

All the pins take their places in straight rows; and this operation goes on so rapidly that, before we can feel sure that one row is finished, we are shown the whole array of twelve rows, containing 516 pins.

From first to last, the cutting, coloring, and folding of all these pins have employed only three persons; and the pins are all much stronger than those that it took eighteen pairs of hands to fashion, or those still earlier made pins that, by law, were not to be sold for more than six-and-eightpence a thousand.

NEEDLES of some kind appear to have been

used in the remotest past. Early savage tribes shaped them out of bones and thorns. In the British Museum we are shown bronze needles three



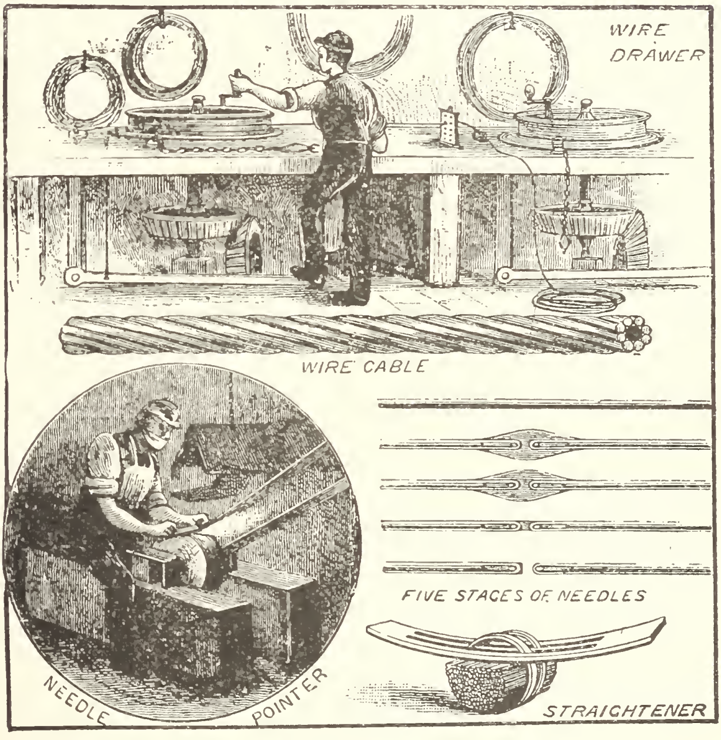
Pin-Folder.

or four inches in length (smaller ones were made, no doubt), which did good work in the world long centuries before the famous stone obelisk known as Cleopatra's Needle was raised in distant Egypt.

It is believed that the first steel needles were made in the fourteenth century by skillful craftsmen of quaint old Nuremberg. It was a German that first taught Englishmen the art of making these very useful little tools, though the knowledge

does not appear to have been considered of much importance.

In a cyclopedia not forty years old we read that "every sewing-needle passes through the



Making Needles.

hands of 120 different operatives before it is ready for sale." So that before machinery came to aid needle-making, this trade must have been slow and tedious work. Many women and children were employed in it, and were miserably paid, while the

needles themselves were much more expensive than they are at present.

One part of the work reserved for lads was the eye piercing. After the father or the mother had flattened the head by a hammer, the needle was passed on to a boy, who, placing it on a steel block, held the point of a piercer downwards on the head, and gave this implement a tap on the upper side; then, turning the tiny bit of steel, he dropped another blow immediately over the place he had just struck.

The needle was next passed to a second boy, whose business it was to trim and to shape the rough hole into an "eye." He used to lay the needle on a piece of lead, and then he deftly drove a tiny pointer into the opening made by the other boy. Then putting the needle on a steel rest, with the little punch still sticking through the hole, he gave the punch a tap with his hammer. This last stroke made the opening, or eye, take the shape of the pointer employed.

Some of those little fellows became so dexterous through constant practice that they could trim the eyes of 400 needles in an hour! Oftentimes a boy trimmer would astonish lookers-on by piercing holes in hairs, and threading these through one another so as to form an almost invisible chain.

Any one who has ever used a needle can easily

believe that its value depends on the quality of its steel. Needle-makers do not make or "draw" their steel wire, but buy it. Let us find a quantity of it in a large needle-making works, and note what is done with it there.

The first consideration seems to be to preserve each bundle of shining wire from rust. All the coils are covered up, and are then hung round the dingy room (a warm one) on wooden bars. The wire in the bundles is of different degrees of thickness, and is measured by means of a steel gauge, which has cut in it small, numbered slits of different sizes. Into each slit a sample of wire is fitted.

A coil weighs about fourteen pounds, and is twenty-four inches in diameter: if it were smaller, it would be more troublesome to straighten the short pieces into which it will presently be cut. The length of the wire in each bundle varies according to the wire's thickness; and there is, as you know, a great difference between No. 1 and No. 12, which are the extremes of the sizes of ordinary sewing-needles.

We can count only twenty-two thicknesses of wire to the inch in No. 1, while in No. 12 there are two hundred. If we were to straighten out this No. 12 coil, it would stretch over a mile and a quarter. Imagine what different styles of needles these wires will in turn form! Some needles will

be almost as thin as hairs ; others will be stout and strong enough to pierce through canvas, thick carpets, or coarse sacking.

Some will bear behind them an almost invisible train of the finest silk thread ; others will lead along packthread or twine. There are also higher-priced needles, such as surgeons use for sewing up wounds. Those needles are not fashioned at all like ordinary ones. Every surgical needle is made singly, and is ground and polished by hand.

Some of the great coils are being carried off to the "cutting-shop," where they are snapped into many thousand lengths of two needles each. As these little pieces have lately formed parts of a circle of wire, they must be straightened. Straightening the lengths of steel wire is a curious process, and one well worth watching ; so come along to see it, and open your eyes wide.

This work was at one time done by hand and mallet : a tedious enough labor it must have been. Now the worker half fills two strong iron rings with the cut lengths of wire, and using a curved bar of iron with a handle at each end and two openings near its center, he places the rings with the needles in them on a flat iron plate with a fire under it.

The slits in the iron bar pass over the rings, and the bar rests on the projecting ends of the wires.

Holding fast the handles, he moves the rings, pressing heavily as he rolls them up and down. In a few minutes he makes the bits of steel as straight as new needles should be.

The next operation is "pointing." Until lately this has been a dangerous and distressing task. Seated in front of a large revolving gritstone, the grinder took up a handful of the wires to be pointed, and held their ends on the stone, pressing them with his other hand, turning them about until they finally, amid a shower of flying sparks, showed the long, tapering points he had been aiming to produce.

But the stone-dust, getting down his throat and settling on his lungs, caused the poor, hard-working grinder a painful disease known as grinder's asthma.

Many humane and skillful men tried at various times to introduce improvements on this dangerous method of pointing needles; but, strangely enough, the grinders themselves opposed all innovations that, by decreasing the danger of their task, might also decrease their wages. When pointing machinery was first brought to Redditch, England, in 1844, the pointers, enraged, rose in a body and destroyed it, declaring that they would be ruined by such aid!

But time works wonders; and now needles are

pointed at the rate of 40,000 an hour by means of a machine (invented in Germany), the use of which has saved many a life.

This machine consists, principally, of a revolving wheel, onto which the wires drop from an inclined tray, and are held fast by an india-rubber band. As the wheel turns, the ends of the wires meet a grindstone which points the wires perfectly. The dangerous grit-dust produced is safely disposed of by a fan exhaust which draws it down a tube.

Let us now observe how some of the skilled workers in this factory make the eye, that important part of a needle. Unless the eye is carefully perforated and finished, it will cut the thread. To see how the eyes are made, we must pass through to the "stamping-shop."

The stamping-machine is a solid block of stone, with a mass of iron on top. On the upper side of this iron part is placed the under half of a die. Above this half-die is hung a hammer which weighs fifty pounds, and on the face of this hammer is fixed the upper half of the same die.

Into the lower half-die a man steadily drops the steel wires one by one, bringing down the hammer every moment. The wires slip into an iron pan, each wire having now a channel, a slight depression to show where the eye will be. So rapidly is

channeling done, that one worker alone has prepared in one hour almost 8,000 needles for the piercer.

Piercers work at small hand-presses. These men must have good eyes and skillful fingers. The pieces of wire are placed upon an iron slab, the sharp points being collected in the hand. Hardened steel pins cut two little holes near the center of each wire; but these eyes are far from complete, and have to be filed — that is, the roughness left by the stamping must be smoothed away. Next, well-skilled workers take the wires, and snap them into halves.

But these unfinished needles would bend very easily, and so they must be hardened — that is, they must be spread out on iron plates, and be then placed in a furnace wherein the wires bake until they are white-hot. They are then withdrawn, and put into a vessel which is filled with oil, and left in it till they are cold. Afterwards they are washed in alkaline liquor, and dried.

They still need to be tempered. Tempering is done by rolling them on an iron plate with a fire under it.

To make them look bright they must be "scoured." To see this curious process, we must go down-stairs to the scouring-room. Here men

are engaged in arranging large numbers of needles in bundles on pieces of canvas. Among the bundles they place portions of a compound of soft-soap, oil, emery, and fine sand. The needles are then rolled up into parcels, which are corded round tightly.

These parcels are then put under heavy slabs weighted with iron and moved by steam-power. Hundreds of thousands of needles, thus arranged, are rolled about for a week.

At last they are put into an apparatus like a sieve, and are so dexterously shaken that most of the needles arrange themselves side by side. They are then easily picked out and placed in neat little heaps ready for the "headers," who next take them in hand to turn all the heads one way. While we are watching the rapid movements of their deft fingers, each tangled heap has fallen into rank and file, — the heads one way, the points another.

Then comes "picking for crooks," that is, picking out all the crooked and defective needles. This work women do, by rolling over and over single layers of needles, and removing all those that are in the least imperfect. Of course the imperfect needles are numerous, but the workwomen's quick hands soon sort them out. In some mills even this sorting is now done by machinery.

At last we are bound for the finishing-room. Here we find two lines of grindstones, all revolving rapidly by means of steam. The grinders apply the ends of the needles to the small stones, which rotate so swiftly that our dazed eyes cannot follow their turns. Finally, the polishers finish the needles on small rotating wooden wheels, whose tires are covered with putty powder.

The making of needle papers employs many people. We are shown some ingenious machines which cut and fold such papers so expertly that by their aid women-workers can each count out and neatly paper about 3,000 needles in one hour. We cannot help thinking that needles enough must be papered in a day to serve the world for a year; yet from one Connecticut needle-mill alone about two hundred million needles are annually sent on their travels!

When we remember that there are also large needle-factories in France, Germany, and England, we wonder at the amount of sewing that must be constantly going on all over the globe.

Before leaving this place, let us peep into those shabby little bags from which we have seen the needle-scourers so frequently helping themselves. We find that all the bags contain shining blue-brown emery. This substance is much employed not only by needle-makers but also by cutlers,

locksmiths, jewelers; by lapidaries in the cutting and finishing of precious stones; by opticians in the preparation of lenses; by glass-grinders, marble-polishers, and many other workers.

What, then, is this useful substance, and whence do we get it? Emery is a mineral consisting mostly of alumina combined with a small proportion of iron, and is found in masses lying imbedded in rocks in various parts of the world. Mines of emery are worked in Turkey, Persia, Sweden, and the United States.

The big lumps of this mineral have to be broken into small pieces, and these are ground into powder in large iron mortars. This powder is then sifted through sieves having networks of different-sized wires. According to the distance between the wires, the powder that each sieve retains is numbered. This numbering is a great convenience to the worker. By it he finds at once the kind of powder that he requires, whether in its dry state or in the form of emery cloth or paper, — things easily made, powder being sifted on both materials while they are newly coated with glue.

Lesson XIV.

Other Useful Articles.

The inquiry is very often made, "What becomes of all the pins?" That inquiry is, of course, altogether unanswerable. But can anybody tell me what becomes of the penknives?

Think of all the schoolboys that are continually getting new knives, either by expending part of their own pocket-money, or, more often still, by receiving them as gifts from good-natured friends and relatives. No matter how lately a lad has been presented with a new pocket-knife, it is sure to have vanished "somewhere," — that great limbo of schoolboy property where everything was last seen.

A penknife is a trifle scarcely worth reading about, you may think, yet a good three-bladed knife goes through over a hundred processes in making. A firm in Pittsburgh, the great center of our cutlery trade, turns out every week 1,500 dozens of penknives.

To watch the making of a pocket-knife, we must first peep into one of a number of small, dingy-looking rooms, in which we shall find men at work beating out blades, which, if for spring-knives, are

made of cast-steel. On one side of the apartment a bright fire is burning. Near it is a large trough full of coke, specially prepared.

A forge-man is busily employed working a bellows with one hand, while with the other he frequently takes out a red-hot bar of steel, the end of which reaches to the center of the fire. This bar he carefully examines, for the proper heating of it requires great skill, care, and experience. If the steel gets over-heated, it becomes useless, and if not heated enough it will not have acquired the softness necessary for shaping it into blades.

When the forger judges the metal to have arrived at the right degree of heat, he places the end of the bar on his anvil, and quickly "strikes" it into a blade, using a hammer, the size of which depends upon the work he has to fashion: for small penknife-blades the hammer's striking surface does not extend over an inch. When the blade is thus roughly struck into shape, it is cut off the metal bar, which is again heated, to go through the same process. The blade is placed ready for the "grinder," whose business it is to grind the tang, — that is, the top part, which is to set into the handle.

We follow a box of blades down into the marking-room. Here they are heated to a color called "worm-red;" then they are one by one placed

under a heavy steel punch, which, driven down by a blow of a large hammer, leaves the name of the maker clearly cut on each blade.

While the blades are still worm-red, the little dent, by means of which a boy opens his knife, is rapidly chiseled on every blade. The bundles of marked blades are now returned to the forger. They have to be hardened and tempered, — two most important processes upon which their usefulness will depend.

The hardening is done by heating the blades until they are at a particular point of redness, and then plunging them into cold water; but, as this operation renders them not only very hard but also very breakable, they have to be subjected to further treatment. The blades, having been cooled, are rubbed in fine sand to clean them thoroughly, then they are laid on a steel tray, and are put into a kind of oven to bake until they show a deep blue tint.

When they have been hardened, tempered, and ground, they are handed over to the fitters, each blade being supplemented with its set of rivets, "bolsters," "pins," and other portions necessary for fitting up a knife.

Here is a fitter just setting to work at a neat, four-bladed, pocket treasure. The principal parts are the blades, the steel spring, or back of the

knife, and the outer and inner scales. The spring is filed down to the thickness of a blade, and is slightly bent, to help the blade's movement. After being rubbed on a wheel whose tire has a surface of glue and emery, the spring is further polished on a steel burnisher, in order that there may be no unevenness, or "catch," as the knife closes.

The handle is composed of an inner scale and two outer scales, the inner one, made of brass, forming those divisions into which the blades fit so nicely; the outer ones of the knife that we are watching have neat covers of creamy ivory. Now follows the drilling of the holes, and then comes the fitting of the rivets that are to hold the various parts together.

We are satisfied now that the making of even a pocket-knife is worth reading about. Its construction employs, as we have seen, forgers, grinders, spring-makers, scale-makers, fitters, polishers, and steel-workers, even after the poor miners, deep in the earth, have provided the metal. Very likely the African elephant-hunter has furnished the material for the handle, at the peril of his life. But common pen-knives are now made by machinery.

Having seen much concerning knives, let us now learn something about forks, whose use was formerly so little known in England, that in a quaint book, published there in 1611, the author writes: —

"I observed a custom in all those Italian cities through which I passed that is not used in any other country that I saw in my travels. Neither doth I think that any other nation of Christendom doth use it but only Italy. The Italians and also most strangers that are in Italy do always at their meals use a little fork when they cut up their meate.

"The reason of this their curiosity is, because the Italian cannot by any means indure to have his dish touched with fingers, seeing all men's fingers are not alike cleane. Hereupon I myself thought good to imitate the Italian fashion by this *forked* cutting of meate, not only while I was in Italy, but also in Germany, and oftentimes in England since I came home."

The use of forks was at first much ridiculed in England, and was regarded as a piece of affectation. In an old play, "your fork-carving traveler" is spoken of with much contempt. Ben Jonson, who was a famous author and friend of Shakspeare, writes :—

> "*Sledge. Forks!* What be they?"
> "*Meercraft.* The laudable use of forks,
> Bought into custom here as they are in Italy,
> To the sparing o' napkins."

At one period of English history loaves of bread were made round. When about to be eaten, they

were cut in slices which were piled by the side of the carver. He had a pointed carving-knife, and a skewer of bone, silver, or gold, which he stuck into the joint of meat. Having cut off a piece, he placed it on a slice of bread, which was thus served to the guest.

This ancient custom of serving meat on bread was once general throughout the continent of Europe. A leg of mutton always had paper wrapped round the shank. This paper the carver took hold of with the left hand when he carved the joint; and such a custom of protecting that part of the roast meat which must be handled still prevails in South Germany and Italy.

For a long time only very particular folk thought forks at all necessary. They were considered to be merely articles of luxury, used by the great lords of the land for eating fruits and preserves. Dainty-mannered guests usually brought their forks with them, as a host could scarcely be expected to keep a supply of such fanciful unnecessaries. The earliest specimens of forks, — iron, steel, or silver ones, were in shape more like split spoons than anything else, and had only two prongs. Table-knives were invented in the sixteenth century; and prior to that period the ordinary cutting-knife was a very important article. Each guest provided himself with a knife for table use. In the hall-way of every man-

sion there was hung a whetstone, for the benefit of all comers whose knives had dull edges.

But while I have been talking about those old-fashioned forks, a grimy forger has been heating a bar of steel of which he proposes to make a neat modern fork. At one end of this bar he, by means of his anvil and hammer, forms the tang, or end that is to go into the handle. Then he shapes the shoulder, and the shank, or middle of the fork, at one end of which he leaves a piece of steel.

This piece he hammers out until it is of the length and width of the prong end of a fork. Another worker then takes the future fork, and having made it very hot, lays the flat end in the lower half of a steel die. The upper half is allowed to come down on it then with a heavy blow. This operation leaves three prongs roughly formed and ready for the grinder, to whose noisy "mill" the fork is carried. Then it is taken to the shop to be hafted, or fitted with a handle. Finally, it is polished.

Steel forks have, of late years, been superseded in many homes by elegantly shaped electroplated rivals, which present the appearance of silver. But to understand the "how" of the dainty modern forks and knives, we must fly to the busy little city of Meriden, in Connecticut, and learn something of electroplating.

We are fortunately just in time, for in the large

factory we happen to visit, workmen are mixing three molten metals into one compound, of which forks, spoons, fish and dessert knives, and other useful things are to be cast. We are shown the great melting-pots full of a gray liquid, composed of copper, zinc, and nickel, — the metals that form the compound metal which, when plated, we generally term silver-plate.

At the right boiling-point the melting-vessels are lifted out of the furnace, and after much stirring and skimming, the metal is cast into ingots, weighing about eighteen pounds each. This operation is called "strip casting;" and a very hot, tiresome task it must be, judging from the appearance of the several workers. The gray strips are next heated in annealing furnaces, and then are allowed to cool before being passed through iron rollers worked by steam.

The metal plates, having been thus cast, and annealed, and rolled to a given thickness, are next cut into pieces, and punched into "blanks," or flat outlines of the forks or spoons required. This punching is done by means of fly-presses, the cutters of which come down upon the metal.

These odd-looking, flattened-out forks and spoons are again annealed, and their handles are stamped with the pattern that they are intended to bear. Any roughness is then filed off, and the blanks are

taken to the "bowler-shop," where there are several workers "bowling" the flat spoons, or bending and rounding the prongs of the forks.

The hammer of the stamping-machine has grooved sides, and slides easily up and down between two posts. The blank spoons and forks are passed rapidly under the hammer and between two dies, which stamp them into form. Of course, when the "bowl" or bend varies in size or pattern, the dies have to be changed.

But now for the magic electroplating bath, which is to transform all these plain metal objects into silver — or, at least, into something very like it. This curious apparatus consists mainly of two parts; the voltaic battery, from which the electric current is obtained, and the vat in which the silvering takes place.

The battery has three large cells (earthenware jars), or more, according to the quantity of electricity to be generated and the intensity of the current which is required. The plating-vats, or depositing-troughs, contain a solution of cyanide of potassium diluted with water.

Across each vat two brass rods are laid lengthways; on these are copper-wire hooks, on which the forks, spoons, or other articles to be plated are hung, after having been boiled in alkaline water, to cleanse them from all impurities. Thin plates

of silver are so strung at regular intervals in the vats that they face on both sides the articles to be plated.

A connection is formed with the galvanic battery, and the silver, released in minute particles from

Electroplating and Gold-leaf Making.

the plates, rapidly attaches itself to the surfaces of the metal objects, the thickness of the deposit depending upon the time the articles are allowed to remain in the bath. An ounce and a half of silver to a square foot of metal is considered heavy

plating, though, of course, more silver can readily be deposited.

When the electroplating is finished, — the process takes from three to six hours, according to the quality of the plating required, — the articles are removed from the depositing-vat, are then boiled in clean water, and are dried in sawdust. They look unattractive as yet, but they will brighten up after they have been passed under revolving brushes, and have undergone a thorough rubbing with sand. The brushes are not composed of bristles, but of fine brass wires, that do most effectual work, and prepare the plated objects for the workers who wait to burnish each one of them with blunt tools.

Next, the articles are polished with chalk to make them more silvery-looking; and then they are packed for the stores, or placed side by side in pretty velvet-lined cases, — the making of which supplies work for many industrious men and women, — and in these cases the plated ware looks very tempting indeed.

Lesson XV.

Fasteners.

You know that the United States uses, for building purposes, more lumber than any other country. As one piece of wood is fastened to another usually by nails, you will readily guess that these humble bits of iron are the fasteners which we are to read about in this lesson.

How many distinct kinds of nails are made? Dozens! And the sizes and varieties of these kinds are numbered by the hundred! Formerly all nails were wrought by hand. They were then, of course, both scarce and dear. The extensive use of wood here early created a demand for cheap and abundant supplies of those useful little iron holdfasts.

Even in our colonial days, the need of low-priced nails was so keenly felt that intelligent artisans tried again and again to invent a good nail-making machine.

Before the beginning of this century, twenty-three patents were granted for improvements in the production of nails by machinery. Over three hundred such patents have been issued since!

Truly, we Americans are ingenious people, are we not?

For years after machine-made nails had been on the market, people believed that clinch nails, like those used in horse-shoeing, could be made only by hand-forging.

But, twenty years ago, manufacturers learned how to anneal the common cut nails; that is, how to put them through a heating process which toughens them, so that they can be bent without breaking. The means of heating, and the machines for shaping the nails, were rapidly improved; and hand-forged nails have not for several years been much used in the United States.

In England, at one time, about 60,000 persons — men, women, and children — worked at nail-making by hand. Even to-day, if we should ramble around the outskirts of the smoky little city of Dudley, we should see, here and there, a small nail-forge in a grimy cottage, or, perhaps, in a wretched shed adjoining some humble cabin.

Hand-made nails may still be bought in England. The nailers there are forced to compete with machines, in order to make a living.

Look into one of those smoke-blackened huts, wherein human beings toil all day, turning iron rods into nails. And remember the price paid for forging the nails — a halfpenny a dozen!

You peer in — and start back in surprise. Yes, the nail-maker is a woman! That ragged little girl, laboring painfully at the bellows, is her child.

The father is, no doubt, working hundreds of feet under the ground in some one of the coal-mines near by. He, too, earns but starvation-wages. Life is hard for him and his family. Are you not glad that the mothers of our own favored land are not compelled to toil all day long, forging iron, like the poor nailer-women of England?

Wrought nails are made out of plates of rolled iron. These plates are slit into strips by machinery, which, also, cuts the nails off lengthwise. The cut blanks are next molded, between dies, into the required form. Then, other steam-driven tools finish the heads. All these operations are done while the iron is hot.

Cut nails are made thus: strips of cold iron, each one as wide as the length of a nail, are placed in a feeding-device, which draws them under cutters. These slice off tapering blanks from the ends of the strips. A cut nail has shank and point formed at the same time, but an additional stroke is necessary to shape the head.

A large proportion of the cut nails now used are made from Bessemer steel. They are much stronger than iron nails. Yet the inventor of the Bessemer process was urged on to his wonderful

discovery by the widely felt need of using steel rails instead of iron ones on railroad tracks.

Now, steel, being cheap, is used for many purposes for which iron would not be strong enough. Thus, we see that a useful invention may be valuable in ways that could not be foreseen at first.

Steel-wire nails have lately come into extensive use. They have great holding power, though they are light and smooth. These nails, also, are made by machinery.

The end of a reel of wire is caught by grippers, and receives a blow from a punch, the nail-head being formed thus. The wire is then pushed forward the length of a nail, two hammers, peculiarly shaped, fashion the point, and a chisel cuts off the finished nail.

Since 1889 a variety of nail has been made of tin-plate scrap. This substance is sheet-iron coated with tin.

The tin-plate is cut into blanks, and these are rolled into round nails. The machine for making them is the invention of a Philadelphia mechanical engineer. It performs the several nail-shaping operations — cutting, gripping, rolling, heading, and pointing — so rapidly that the eye cannot follow its motions.

A nail-making apparatus can turn out a thousand

nails a minute. How vastly superior to the fastest hand-nailer is such a machine!

Still, in the old hand-working days, some of the nailers became, through constant practice, very expert at their trade. It is on record that a workman in Smethwick, England, made, in two weeks, 40,800 floor-nails!

To accomplish this wonderful feat, he had to heat his nail-iron 42,836 times, to weld together large numbers of short bits of iron, and to strike each nail twenty-five blows. He was a remarkable worker, was he not?

Lesson XVI.

The Three Great Ages.

In nearly all parts of the world, learned men have found proofs that for thousands of years people knew nothing about the useful metals. All weapons of war, all tools, were made of flint, or of wood, or of animal bones. As the best weapons were fashioned out of stone, this period of human history is called the Stone Age.

After centuries of practice in working flint, men finally learned to make, out of this hard material, implements of much beauty. Several great cities

of Europe have museums in which may be seen stone arrow-points, spear-heads, axes, and hammers that are finished with rare elegance. Visitors seldom fail to admire them. Yet all those beautiful weapons were made from lumps of flint, simply by rubbing each lump with another flintstone!

Among other relics of this stage of human progress, we find querns, or hand-mills for grinding grain. The earliest form of hand-mill consisted of two flat stones, between which the barley or rye was bruised.

The best mill for hand-work was composed of two heavy stones, somewhat resembling our mill-stones. There was a large, funnel-shaped hole in the upper grinding-stone. A small hollow was drilled about two inches into the lower stone, and a tough stick was used to hold the two grind-stones together.

The grains or seeds were poured into the opening in the top stone, which was the grinder, the stone that was whirled round to turn the grain into flour.

Pins, combs, and hooks were shaped from the bones of fish and of wild animals; shells were employed for dishes, and cooking-vessels were molded of sun-baked clay. Jewelry was not forgotten. Then, as now, vanity was one of the strongest of human passions. The women of that

time bedecked themselves with large necklaces and other ornaments carved out of soft *coal.*

During the thousands of years which passed before the Stone Period ended, man may be said to have been a hunter or a fisher, dwelling in caves, or in huts formed of tree-boughs, or in hollows in the surface of the earth. The skins of animals served as his clothing.

His boats were merely hollowed logs. Several of those ancient canoes have been dug up on the sites of great modern cities. In 1887, some laborers digging a cellar in Glasgow, Scotland, found, twenty-eight feet below the surface of the soil, a log-boat about sixteen feet long. Scientists that inspected it said that it was at least 6,000 years old.

How was such a canoe made? The people of the Stone Age knew nothing of iron or steel. They had none of the modern boat-builder's tools, — fine saws, axes, planes, augers, chisels, squares, adzes, and draw-knives.

Starting a fire around the trunk of some huge tree, the canoe-maker tended it from day to day, constantly hacking off, with his flint ax, the charred portions, in order to allow the flame to eat away the green wood.

By the same method, after the tree had fallen, he got rid of the limbs and branches, and also

reduced the trunk to the desired length, — the length of the canoe he was going to make. A line of fire was kindled along the tree, and was carefully fed ; but was allowed to burn in certain directions only.

When the fire, aided by blows from his stone ax, had hollowed out the log deeply enough to suit our early shipwright, he embarked in the rude craft, and then easily obtained more plentiful supplies of food for himself and his family. He could use the boat for fishing, for hunting along river banks or the sea-coast, or for trading with neighboring shores.

At even that early time some traffic was carried on between distant tribes. In many places where several families evidently lived near one another, searchers have found spear-heads, knives, hammers, and other weapons fashioned out of stone that does not occur within hundreds of miles. Those articles must, therefore, have been obtained by bartering with the people who made them.

The use of fire is one of the great distinctions between man and the lower animals. All brute creatures are afraid of fire. No doubt, early man employed it to frighten away beasts of prey by its brightness and flame. Its smoke also must have been utilized to keep stinging insects out of hut and cave.

It was probably soon discovered that meat dried over the fire did not decay so quickly as raw meat. Perhaps the art of cooking could be traced to this mode of preserving animal flesh.

As all fires were kindled on the ground, people must soon have noticed that fire hardened earth, and then they would quickly perceive that vessels of burned clay would last longer than those baked in the sun.

Man's first hint of the working of metal came, perhaps, from the melting of copper by a stream of lava flowing from a volcano; or, it may be that some savage having lighted a fire on a few lumps of the ore of some metal, thereby fused those lumps, and thus produced a substance new to him.

If he took this smelted metal in his hand, and examined it, he could not fail to see that, as a material for making weapons, it was much superior to flint. When man learned even a little about metal-working, he began to advance rapidly toward a higher civilization.

The Age of Stone was succeeded in most countries by the Bronze Period. The metal first worked was — not iron, but copper. In many parts of the world, copper is obtained nearly pure, and, therefore, fit for hammering into any desired shape.

Gold and silver seem to have been known in very

early times. But these metals were too scarce, as well as too soft, to be used for such implements as men needed then. It is quite probable that gold was the first metal generally known, because it is the only metal found in an almost pure state on the earth's surface. Hence gold could be procured without much labor, neither mining nor smelting being required.

Utensils of copper have been unearthed in various localities in Europe. This metal is too soft, however, to make good cutting-instruments. Smiths must have early tried to harden it. We may safely assert that it was at a very remote date that tin was first added to copper, thus forming the hard metal that we term "bronze."

This compound melts at a temperature lower than would fuse either tin or copper, and is, therefore, more readily worked. As bronze weapons kept their edges sharp for a long time, the new metal soon came into extensive use.

Ancient bronze articles consist of seven parts copper and one part tin. Is it not strange that, no matter where an old piece of bronze has been found, — whether it be a broken knife from Asia Minor, or a battle-ax from Denmark, a coin from North Africa, or an arrow-head from Ceylon, — the metal has always the same proportions of tin and copper?

Would not this remarkable fact lead us to be-

lieve that all the tribes that made bronze got their knowledge of it from the same source?

Old historians tell us that tin was mined in only two places,—the south-western district of England, named Cornwall, and the island of Banca, in Malaysia.

The Phœnicians, a great trading people who inhabited the sea-coast of Syria, brought from England tin ore to be smelted in their busy cities of Tyre and Sidon. Cornwall had no copper mines, Banca had dozens of them. Even to-day this island exports large quantities of copper; and more tin is still mined there than is produced in any other part of the world.

It is, therefore, probable that the secret of making bronze was discovered in the East, and was brought to the West by merchants. Through commerce, then, the Stone Age came to an end in Europe.

In the north-western portion of our own continent, the native tribes used stone hatchets and knives until recently. It is only within our own day that similar weapons have been thrown aside by the Pacific islander for steel ones got from white traders.

There can be little doubt that the tin of Cornwall, England, helped to harden the spear-heads and shields of Grecian warriors—to make

the brazen chariots of the monarchs of Syria, and even the bronze pillars of Solomon's Temple. The pillars were molded by Hiram, King of Tyre, who, we read in the Bible, was "filled with wisdom and understanding, and cunning to work all works in brass."

How much we American children would have liked to see those magnificent columns, — products of the Tyrian ruler's skill, — and all the other wonders of the grand and famous temple!

At the beginning of the Bronze Period we meet with traces of a wide-spread commerce. The bold sailors of Phœnicia carried the metal articles cast in the East to the people of Western Europe.

Relics of the Age of Bronze have been unearthed in most European countries. In Mexico and Peru bronze battle-axes were employed by the natives in their brave but fruitless struggles against the invading Spaniards. Yet descendants of those Indians make, even at the present time, various household utensils of sandstone.

The change from stone to bronze was effected only very gradually. The powerful chief might be able to buy a bronze war-hammer, while the poor subject would be forced to content himself with a stone weapon. Apparently stone never went entirely out of use till iron appeared.

Though iron is one of the most widely diffused

of the metals, it never occurs in nature in a pure state, except in meteors, but is found only in the disguised form of its ore. To extract iron from the ore requires more knowledge than is needed to work pure metals. Hence, before the use of iron became common, people had learned a good deal about gold, silver, copper, tin, and the compound metal, bronze.

According to several ancient historians, iron was revealed to mankind by accident. The forests on Mt. Ida, in Greece, were set on fire, and large quantities of ironstone on the mountain's surface were fused by the intense heat.

After the fire had partly burned out, some wood-gatherers, venturing up the mountain, found a mass of the new metal. Whether this account be true or not, it is generally agreed that iron was discovered by chance.

The first smith that took advantage of this discovery, and smelted iron-ore, benefited the human race very greatly indeed.

When we consider how much we are indebted to iron tools and machines for their aid in procuring us food, in preparing our clothing, in building our houses, in carrying us from town to town, and in making our lives more comfortable in a thousand other ways, we then perceive that modern civilization could not exist without this invaluable

metal. Even the youngest pupil can now understand why our own time might be appropriately called the Age of Iron.

A higher grade of living became possible when men discovered how to tame animals. Horses, cattle, sheep, camels, goats, swine, dogs — all these brute creatures once ran wild.

Man, having learned how to rear them, was no longer obliged to risk the dangers of a wild-beast hunt in order to obtain meat food. Some of his animals supplied him with milk also; others were of great service to him in carrying his household goods when he wandered about in search of better pasture for his herds.

When their fields had been cropped of grass, pastoral people were accustomed to drive their flocks and herds from place to place until good pasture-land was found. Even nowadays the Turkomans of Central Asia, thousands of Arab families, and various African and South American tribes live in this manner.

Tents are the homes of herders. Perhaps the simplest form of tent is the one made by tearing off a large tree-limb, bending it into an arch, and forcing both ends of the limb into the earth. The branches are left on, and over them is thrown a cowhide for roof.

The Hottentots of South Africa, and the Gaucho

Indians, who range over the South American pampas, or plains, sleep in tents made, each, of four poles and an ox-skin. The red races of North America built their wigwams in stronger style, by driving long stakes into the ground in a circle, pressing their tops to a point, and covering the whole skeleton cone with bark.

While roaming around with their droves of live-stock, people would naturally seek new and more convenient ways of getting food, clothing, and the means of shelter. When men learned how to work metal, they began to lead a more settled life and to till the soil.

We must note, however, that though the Hunting, the Pastoral, and the Agricultural states of life followed one another, in the order named, in Asia and in the greater part of Europe, yet, in our own country, the native tribes never were herdsmen or shepherds.

Cattle and sheep were unknown on this continent until they were brought here by European immigrants. Corn grew plentifully, and the immense forests of the three Americas gave both man and beast large supplies of vegetal food. Our Indians seem to have had, in even their remotest past, some knowledge of farming.

In settled society, man has taken care to build for himself a strong house. It was made of wood

first ; afterwards of stone. His dwelling-place afforded him shelter from stormy weather, and also served him as a fort against the attacks of his enemies.

Is it not interesting to learn that the most striking examples of early mason work are to be seen in America ?

In Southern Mexico the ruins of vast temples and palaces have been found near the villages of Uxmal, Palenque and Chichen.

Explorers have met with one edifice that must have been a quarter of a mile square ! A kind of brown cement was used to keep its huge blocks of stone together. This immense structure was, probably, the national temple of the people to whom historians have given the name *Mayas*.

That strange race must have perished hundreds of years before the Aztecs entered Mexico. Our geographies tell us that the Aztecs were those partly civilized Mexican Indians that fought so desperately for their country against the Spanish invaders, who finally subdued them in the first half of the 16th century.

Lesson XVII.

Strange Tree-Products.

The Venezuelan "Milk-Tree" has long been known to botanists. It is one of the noblest of forest trees, and rises, with straight stem, to a great height. The timber is hard, fine-grained, and durable.

Singularly enough, it is from the bark that the milky juice is obtained. A cut being made in the bark, the milk, which is almost as thick as cream, flows out. It is caught in clay pans, falling into them through wooden spouts. This creamy sap mingled with tea or coffee improves the peculiar flavor of either beverage.

The tree-milk, after being exposed to the air for a short time, begins to thicken, and soon becomes a kind of glue. Were it not for its unpleasant taste, this sap, when fresh, could not be distinguished from cow's milk, except by a chemical test.

A careful analysis of this vegetal fluid shows that it is made up of the very same elements of which ordinary milk is composed — fat, sugar, casein, mineral matters, and water.

Perhaps no other trees are so valuable as the

Pines. They furnish the world with the kind of lumber which is the most extensively used — that fact we all know.

But would you readily guess that their needle-like leaves are now employed to make coarse wrapping-cloth for cotton-bales?

An ingenious American mechanic has recently patented a machine that uses pine-needles as warp material in weaving heavy bagging — the rough, cheap fabric with which baled goods are generally covered.

In south-western Austria the farmers utilize pine leaves for cattle-fodder. They are collected from tree-boughs cut off in the spring. These boughs are piled in barns, and are left exposed to free currents of air until the leaves fall off. Then, after being kiln-dried, these are ground into powder in mills. Salt is added to this powder, and the mixture, when mingled with finely cut straw, may be fed, with advantage, to farm-stock.

What pupil of this school knows the origin of that strange, beautiful substance called "amber"? It has an interesting history.

In the Middle Ages people believed that amber was made of sea-birds' tears which had grown hard under a tropical sun. A mystic power was, in those times, imputed to even the smallest bit of this fine, hard material.

Weird superstitions connected with amber form the basis of numerous old German fairy-tales, and have afforded themes for ballads and stories that are read by young and old even to-day.

The Greeks called amber *electron* — a term implying brightness. Nowadays we often use that old Greek word, slightly changed in form, and totally changed in meaning.

It was through amber's peculiar quality of attracting certain light substances that we moderns were finally led to give the name "electricity" to that powerful and mysterious force which, in numerous ways, is proving so useful.

We all are aware that electricity furnishes light, carries messages, and propels street-cars; but it sounds strange to hear that the same power that makes the telephone a success is also employed to operate sewing-machines, clothes-wringers, boot-blacking apparatus, and fans to cool the atmosphere. There is seemingly no limit to the uses of electricity. It cures ailments, repeats words or music, extracts metals from clay, runs tricycles, and even pulls teeth!

Now, I think you would like to ask me the question, "What is amber?"

It is the fossil resin of a species of pine-tree. Millions of years ago extensive woods of this pine were spread over large tracts of Northern Europe.

The trees seem to have exuded a sticky sap very plentifully in certain seasons. Miners have unearthed fossil pines completely sheathed with amber.

This stone-like resin has proved to be of great interest to men of science. From amber they have learned much concerning the ancient pine forests and their insect life. Those forests, let us remember, flourished, faded, and died eons before man appeared on the earth.

Do you wish to know how such knowledge could be got from mere petrified gum? When the sap streamed down over the limbs and trunks of the pine-trees, insects, alighting on it, were caught, and were held fast.

Often many a captured insect, wildly struggling to escape, gained its freedom at the cost of a wing or a leg. Insects by the thousand — 800 different species of them — have been found in amber from Prussia alone. Tiny leaves that grew in forests destroyed long ages ago have also been preserved in this amber. Examined under the microscope, those leaves are easily recognized as parts of mosses and ferns.

In these days of severe trade competition it would be strange if imitation amber were not sometimes imposed on purchasers. North Carolina resin, chemically treated, is often sold for the

fossil kind. To increase the imitation's resemblance to the real article, insects are pressed into the thick pine-sap from which the resin is made.

Science, however, cannot be deceived. The insects found in genuine amber are all of species extinct thousands of centuries ago. In the counterfeit substance the insects belong, of course, to existing species.

On the Baltic coast of Germany numbers of people make a comfortable living working in the amber fishery. Samland, a village not far from Dantzig, is their headquarters; and the bulk of the world's amber supply is obtained from the shore district of which Samland may be regarded as the center.

Most fishermen avoid storms, if possible to do so, but amber-gatherers are actively at work in time of tempest. Winds and waves are their allies. A raging sea is likely to wash off large quantities of the sand and pebbles that cover the reefs of amber.

Provided with long hooked forks, or with hand-nets, the fishers wade into the foaming water. Some strive to pull ashore the tangled clumps of marine plants, hoping to find treasure therein; others try to scoop up with their nets the pieces of amber seen tossing on the waves.

Masses of seaweed that the men have hauled

up on the beach are carefully searched by women, in the hope of meeting with fragments of the beautiful fossil resin. Only the smaller bits, however, are cast up by the sea. The larger and more valuable pieces are rolled around on the bottom.

To secure those prizes, the workers must wait for a calm day. Then they row out, equipped with full sets of diving apparatus. A boat's crew consists usually of eight men. Six remain on board, and two, wearing diving-armor, work on the floor of the sea.

A diver's protective head-covering bears some resemblance to a huge, brimless, derby hat made of thin steel plates, highly polished, and having a glass eye-piece in front. This odd-looking hat rests on the diver's shoulders, not on his head.

Rubber tubes connected with the diving apparatus enable the men in the boat to send down, by air-pumps, to each diver, a constant supply of fresh air, and to draw away the air which has been fouled by having been once in his lungs.

Two of the boat-hands, holding life-lines looped around the chests of the divers, who are working perhaps 100 feet below, watch intently for a pull — a signal to haul up. The men in charge of the air-pumps labor unceasingly. Even a moment's stoppage of work on the pumps might result in death to the toilers under the water.

Using a heavy three-pronged iron tool, each diver delves among the masses of weed, sand, and pebble that make up the bed of the Baltic Sea along the Samland-shore district.

Sometimes the divers creep about on hands and knees, looking for blocks of amber that may have been dislodged by the last storm.

Once in a while a lump of the precious fossil is found that is heavy enough to require the united strength of two pairs of hands to raise safely. Divers remain under water about half a day. So severe is their work that, though the water is icy cold, they always rise bathed in perspiration.

Off the Baltic coast near Königsberg, steam-boats are employed in the amber fishery. Every fine day they sweep many miles of the sea with large, closely woven nets.

Generally, a fair "take" of bits of the costly fossil resin rewards the exertions of each crew. Amber-gathering is so valuable an industry that the German government derives from it a yearly revenue of about $130,000, by imposing a tax on the amount of amber collected.

"Go, little son, delight of my heart, to our good Wax-tree, and bring me the material for a candle."

Such a command, given by a mother to her son, may be heard any hour of the day in the interior

of Japan. There, candles are not bought, but are made in each household as they are needed.

The wax for the candles is obtained from a certain species of tree. The wax-tree's berries are thickly coated with a yellowish-white wax. This is removed by steaming the berries, putting them in bags, and pressing these by machinery. The wax is forced through the bagging, and is then scraped off into pans. This curious vegetal substance is employed also for waxing thread, and for giving a gloss to collars and cuffs.

In South China the tallow-tree supplies many people with the material for house lights. This tree's fruit contains a white pulp, which, mixed with a little oil, can be readily molded into candles of any size.

Few trees are more hardy and graceful than the birch. Have you ever noticed the beauty of its foliage? The next time that you have a chance to look at a birch leaf, take note of its lovely design.

The uses of birch-wood are too numerous to be described here. In Northern Scotland many articles of table-ware in the homes of working people are made of birch. Russia leather owes its pleasant odor to birch-bark.

Half a century ago country school-teachers used to keep on hand, for the benefit of unruly pupils,

a carefully selected stock of birch twigs. But *I* do not regard this fact as a point in favor of the birch-tree, do you?

Many, indeed, are the ways in which vegetal juices add to the pleasures of life. Sometimes a plant, sometimes a shrub, and sometimes a large tree yields the sap for a medicine, a drink, or a commercial product.

In the case of the extremely useful india-rubber, it is a tree that is the source of the sap. The rubber tree grows seventy or eighty feet high.

Soft clay troughs are fastened around the trunk of each tree that is to be tapped, and, above them, several incisions are made in the wood. The juice oozes slowly out from these cuts, and flows down into the troughs.

At first it is milky in appearance, but changes color soon, becoming light-brown. While the rubber-juice is white, it is often drunk by the native gatherers — Indians of the great Guarani race. The dark color of commercial elastic-gum is caused by heating the thickened sap over smoky fires.

Oftentimes, when trees provide us with some product of use or of beauty, they do so at the cost of their own lives. Yet some trees yield their produce not only without injury to themselves, but they even gain by giving.

It adds to the length of a cork-oak's life to remove the tree's outer bark, which is the familiar cork of commerce. If its bark be not removed, a tree will not live more than half a century; stripped of its bark at certain periods, a tree may reach the age of 150 years.

The cork-oak is a native of south-western Europe, and grows also in Algeria — and grows there very abundantly. When the tree is about five years old, the outer bark becomes spongy and thick. It will crack if left on the tree, and will then be unfit for use.

In cutting off the outer coat of bark, great care has to be taken to prevent the inner coat from being injured. A tree is first circled with a knife in four or five places, and then cuts are made lengthwise down the trunk. The surface is next gently beaten for the purpose of separating the outer bark. This is detached by a peculiarly shaped steel instrument, resembling a short, bent sword.

July and August are the months in which the cutting is done. The curved sheets of cork are charred slightly to close the pores, are piled in stacks, and then are pressed out flat by means of heavy weights. Having been allowed to dry, under pressure, for two or three months, the bark is ready for all the uses to which cork is put.

One of the most useful articles of commerce is made, in western Russia, from a beautiful tree. Who ever saw the aspen's bright, dancing foliage without admiring it? In even the calmest summer day the leaves exhibit the joy of motion, and almost dazzle the observer's eye with the myriad glints of sunlight that they reflect.

Curiously enough, there is a certain likeness between the activity of the leafage and the character of the timber.

Aspen wood is easily splintered, and takes fire readily. Hence, it is just the wood for matches. Near the village of Zarnow, Russia, there is an immense match-factory, in which about 40,000 cubic feet of aspen timber are annually used in the manufacture of those invaluable little light-producers.

Lesson XVIII.

Workers of Old.

Long before the Christian Era, Egypt and the countries in Asia Minor, once inhabited by the Babylonians, the Assyrians, and the Phœnicians, were homes of industry and trade. All those nations had seaports, and were engaged in foreign commerce.

A highroad from India, through Persia, to the eastern shore of the Mediterranean Sea, was a busy route of traffic 3,000 years ago. Multitudes of caravans toiled along it every day; ox-teams plodded over it as patiently, we may be sure, as our oxen work for us; and slaves, laden with bales of goods, crowded the sides of the highway.

The shouts of camel-drivers, urging on their beasts, mingled with the cries of peddlers of magical charms, of salves, of sandals, of leathern bottles, of whips, and of various other wares.

Once in a while a high-pitched trumpet-note shrilled through the air. Then every driver within ear-shot fled with his four-footed companion off the road. In a few seconds a company of cavalry, guarding one of the king's messengers, thundered past the peace-bringing soldiers of commerce.

Along this great highway large public-houses, for the use of travelers, were erected at various points. Those buildings were the oldest hotels of which we have any record.

The huge cities of Nineveh and Babylon, each one occupying about seventy square miles, arose in the same narrow plain — the tract watered by the Tigris and Euphrates Rivers. Yet only a few ruins now mark the sites of those aforetime great

marts of trade, and the once densely peopled Assyrian valley is a desert.

From the ruins we have learned that the Assyrians carried many industrial arts to a high degree of excellence. The potters made vessels of nearly every size and form known to us. It is only a few years ago that we discovered how to case bricks with china-like enamel, yet such glazed bricks are quite common in the ruins of Nineveh.

Assyrian artisans were skilled in glass-making, in metal-working, in cutting marble, in bricklaying, and in manufacturing articles of jewelry. Temples and palaces in Assyria were built partly of stones, held together with mortar, and partly of bricks, cemented with bitumen.

Several of those buildings were erected on artificial earth-mounds forty feet high. Modern explorers have measured the fallen walls on one such tableland, and found that these inclose a square mile. The object of elevating the palaces was to insure a cooler atmosphere for the king and his courtiers.

The great temple of Belus, an edifice that has never been equaled since, rose on eight terraces to a height of 570 feet. This vast building was made of sun-dried bricks, cemented together with a kind of pitch. This peculiar mortar soon hardened into a substance much more solid than the

clay and straw of which the bricks were composed.

Babylon's famous hanging-gardens, which were listed among the Seven Wonders of the world, were not hung in the air, as the name would lead us to believe.

They were square terraces of earth, and were about 300 feet high. Nebuchadnezzar, a king mentioned in the Old Testament, built them to please his queen. Rare flowers and beautiful shrubs covered their tops.

The gardens had decayed only in part in the time of Alexander the Great. Their grandeur in even their half-ruined state amazed that great soldier. What would he have said could he have seen them in all their original glory! With what rapture we young Americans would have gazed on those wonderful structures!

The beginnings of Egyptian history are lost in the night of ages. One short record, written on leather tanned by some unknown method, has been shown to be over 4,000 years old. The Egyptians seem to have studied out for themselves all the secrets of architecture, sculpture, farming, ship-building, weaving, and of many other arts of civilization.

We have no proof that the people of Egypt ever learned anything from any other nation.

The Egyptians were divided into castes, or classes, the highest class being the priests. *These had the most power because they had the most learning.* But the artisans were divided into as many crafts as there were branches of industry. The valley of the Nile was well adapted for the abode of a farming people. Every spring the river overflowed its banks for miles. When the flood subsided, a rich black mud was left on the land. But, though this soil was easily worked, even when it had become dry, still, the farmers in ancient Egypt must have needed tools, as much as these are needed by the farmers of the United States.

The early plows, as they are pictured on Egyptian monuments, were merely instruments for scratching the surface of the ground. However, as population increased, improvements were made in the plow, and canals for bringing water to desert land were cut.

A great Greek writer, Herodotus, sometimes called the "Father of History," informs us that after the fields had been watered by the overflow of the river, "each man sowed his land, and then turned swine into it, in order that the grain sowed might be trodden into the soil by the swine."

The practice of making oxen trample wet ground, on which wheat or rice has been scattered,

prevails in Hindustan and in the Island of Timur, Malaysia, even nowadays.

Grain was reaped by means of sickles. Generally the reapers were slaves. The grain, spread on hardened earth floors, was threshed by drawing wooden rollers over it. Sometimes the flail was used. How slow such methods of threshing would seem to our Western farmers whose wheat is threshed by steam machinery at the rate of thousands of bushels a day!

The art of obtaining flour from grain was well known in Egypt. That country was the Minnesota of the ancient world.

Cattle-rearing formed an important branch of industry, and on numerous early monuments we see depicted cows of fine breed. Usually, they are adorned with collars and bells. Yet no persons but the priests were allowed to eat beef.

The ox was a sacred animal, and altars were erected in its honor. But the hog was deemed to be unfit to be eaten, and even its presence was defiling.

The question has often been asked, "If the Egyptians regarded pork with disgust, why did they raise large numbers of hogs?"

Some historians think that pork was the meat food of slaves; others believe that hogs were kept as scavenger animals. What is *your* opinion?

In ancient Egypt bricks were made of clay and cut-straw. This curious mixture was thoroughly kneaded, and then was put into boxes — each box being the size of a brick — and the clay casts were dried in the sun.

When we visit two territories of our own country, New Mexico and Arizona, we shall see hundreds of dwellings built of sun-baked bricks — "adobes" they are called. This strange term is the name given to such bricks by the first white settlers in our far South-west. What language did they speak?

But why did not the Egyptians harden their bricks by burning them in kilns? Because Egypt was not a country abounding with fuel that could be of any service in the kiln process.

The abundance of firewood explains the rapid progress in the art of brick-making in Europe. We note here, then, that people will not become skillful in any industrial art, as the manufacture of bricks, or of steam-engines, or of clocks, unless the means of pursuing that art be at hand.

Even when we have the means, we must use them, if we wish to be capable workers. There is a good deal of wisdom in the old proverb, "Practice makes perfect." This adage applies to school studies as well as to trades — to penmanship, for example, as much as to diamond-cutting.

The Egyptian style of building is notable for magnificence. The oldest edifices were pyramids and temples. Those immense structures could not have been raised without the aid of machines.

It is, however, the general opinion of men learned in the history of ancient Egypt that the machines were of the simplest kind. Steam or water power was not known.

On the walls of a king's tomb there has been found, carved in the stone, a design that shows how a large statue of granite was moved. The enormous mass is being drawn by eighty-eight slaves, who, in four rows, are guided by a master standing, whip in hand, on the statue.

This stone picture suggests that the huge granite blocks in the great pyramids were lifted into place mainly by the strength of slaves — men that had the misfortune to be captured in war.

Why were the pyramids erected? To serve as tombs for some of the monarchs of Egypt. The Great Pyramid is the largest solid edifice ever raised. Its base covers an area of nearly thirteen acres. Its original height was 480 feet, and its weight is estimated to have been about 7,000,000 tons.

The stones are squared, and are each nine feet long and six and a half feet across each side. Thousands of the granite blocks have been re-

moved and used for building houses in the city of Cairo.

According to Herodotus, 100,000 men were employed for twenty years in constructing this pyramid. The laborers were relieved every three months by fresh relays of like unfortunates.

Other enormous buildings, besides the pyramids, were erected by the ancient Egyptians.

The palace at Karnak has a room 338 feet long by 170 wide. Around the sides are ranged 134 pillars, the caps measuring sixty-four feet each around. One hundred men could stand on the area covered by the base of any one of these pillars.

The effect of this array of splendid granite columns is very grand, especially when the room is seen by moonlight. The gates, halls, stairways, and pillared porticoes of the Karnak palace were equaled in grandeur by the corresponding parts of the great temple of Ammon at Luxor.

Most of the industrial arts seem to have been practiced by the Egyptians. They made ship-cables from the fibers of flax. This valuable plant grew abundantly along the banks of the Nile.

A ropemaker at work, assisted by slaves, is depicted on an old monument.

The master, standing, is engaged in twisting

the rope, while his helpers are twining together the threads of which it is composed. Strong ropes must have been used in towing the large freight-boats which journeyed up and down the Nile, and in hauling the big obelisks. These were stone monuments, and weighed hundreds of tons apiece.

We learn from the Scriptures that ancient Egypt was rich in gold and silver. King Pharaoh, we are told, when he decided to bestow a royal honor on Joseph, "put a gold chain about his neck." The Hebrews, prior to their departure from Egypt, borrowed "jewels of silver and jewels of gold."

On the monuments we see portrayed the series of operations employed in working the precious metals. The gold is being melted in the fire-clay vessels which we call crucibles; men are increasing the heat by blowing on the fire through tubes; next are clerks weighing the refined gold, and, lastly, artisans are fashioning the metal into jewelry.

Statues of gold, of silver, and of bronze were often cast. The tombs of Egypt have furnished us with numerous examples of the workmanship of her ancient goldsmiths; for it was an Egyptian custom to bury articles of jewelry with the dead.

Among other ornaments thus preserved, there

have been found fine necklaces, bracelets, rings, brooches, earrings, and royal crowns. The artistic taste shown in many of these articles arouses the admiration of all jewelers that are privileged to examine them.

The oldest records of mining are Egyptian. On a portion of a wall that once formed part of a great temple in Thebes, there is sculptured a picture of a king offering grain to one of the gods of ancient Egypt — Amun Ra.

Under the picture strange-looking signs are cut in the granite. Learned historians tell us that these signs are words. The meanings of the signs were known only by the Egyptian priesthood.

After much study modern scholars found out what each sign, figure, or character represents; and now the mysterious inscriptions, which once puzzled everybody, can be read as easily as a bright pupil, like myself, can read this sentence.

The inscription on the Theban temple tells us that, about 2,500 years ago, the gold and the silver mines of Nubia, a province of Egypt, yielded, every year, nearly $35,000,000 worth of the precious metals.

It is interesting to trace the history of the smelter's art, noting how the rude methods of former times have been gradually bettered until

finally we have to-day's processes of metal-working, which seem to be almost perfect.

By the old way, as followed yet in Hindustan, the worker must toil a whole week to extract a few pounds of iron from the ore. A large blast-furnace will, in the same time, produce 500 tons of the metal.

In Egypt bronze was, as we have learned, used prior to the invention of iron-smelting. The iron relics which have been found in that country are few compared with the bronze ones, and it is evident that bronze was preferred to iron through the whole history of ancient Egypt.

The Nile valley contains no mine of iron ore, and the cost of buying iron prepared abroad and of bringing it home would tend to limit the use of tools and household utensils made of that metal. Besides, skillful Egyptian artisans had discovered a mode of rendering copper as good as steel in cutting power.

On numbers of the monuments are pictured weapons, armor, and methods of warfare common among the ancients.

The warriors of Egypt marched to battle in close ranks, armed with swords, spears, slings, clubs, and battle-axes; and they cheered themselves onward with strains of martial music. The leaders were clad in bronze armor. The private

soldiers wore suits of quilted linen, and carried wooden shields.

Egyptian houses had their doors hung on bronze hinges, curiously similar in shape to the hinges that we use. Trunks were secured generally by locks having two bolts.

Many of our musical instruments were known to the Egyptians. Cymbals, drums, tambourines, and harps were to be found in every wealthy home along the sacred Nile. The wind instruments consisted of trumpets, fifes, clarionets, flutes, and reeds that produced high or low notes.

Music was cultivated by the priests especially. There has come down to us the record of one royal concert in which 600 musicians took part. Would you not like to have been present on that occasion?

From Babylonia, Assyria, and Egypt the arts of civilized life were spread by the Phœnicians along the shores of the Mediterranean. The great cities of Tyre and Sidon were the chief centers of Phœnician industry.

In Tyre there were many factories in which glass was made. The shops of the metal-workers were so numerous that the immense supplies of bronze and iron articles for war and for household use, and the show-tables heaped with ornaments of

gold and silver, never failed to arouse the wonder and admiration of all foreigners visiting the city.

Weaving and dyeing were common trades. The far-famed Tyrian-purple robes were eagerly sought after by the rich nobles of various countries.

Gold and silver were wrought with great skill. The Old Testament's description of the Tyrian king is very striking: "Every precious stone was thy covering, the sardius, topaz, and the diamond, the beryl, the onyx, and the jasper, the sapphire, the emerald, and the carbuncle, and gold."

The Phœnicians seem to have been a nation of traders. Their merchants went east as far as India, and west as far as England. They taught Europeans the art of writing.

Phœnicia seems to have been the starting-point of modern commerce. To that little country, occupying only a part of the Mediterranean's east coast, mankind is also indebted for great improvements in ship-building and in navigation.

There are very many remarkable points of likeness between the civilization of the Hindus and that of the ancient Egyptians. The East India monuments which have been preserved from the remote past, are hardly less important than the remains of the sculpture-work done by the long-dead stone-carvers of the Nile valley.

The oldest buildings in Hindustan are the cave-

temples, cut out of solid rock-mountains. In these temples the religion of the Hindu reformer, Buddha, was preached to the people.

Agriculture was the principal occupation, especial care being taken to secure abundant harvests of rice.

The weaving of cotton was an important industry, and the methods of the art were the same as those used in Egypt — a country distant hundreds of miles.

Let us remember that, in the far-off ages of which we are speaking, there were no railroads, no steamers, no telegraphs. Did the Hindus send missionary weavers to the dwellers on the banks of the Nile? Or were both India and Egypt pupils of some unknown nation which perished long before Europe entered into the Stone Age?

The extraction of copper and iron from their ores was practiced by the Hindus from a very remote period, and they early attained great skill in metal-working. India steel was an article of trade many years before the beginning of the Christian era.

In China, arts and industries were more flourishing in ancient times than now. While the Hebrews were leading a pastoral life — were wandering about Palestine with their flocks and herds

— the Chinese, who are now half-barbarous, had then reached a certain degree of civilization.

Their chief industries were the manufactures of silk, porcelain, bronze, and iron. The art of enameling metals has been known to this strange people from a very early date.

The Chinese boast that they have taught Europeans and Americans how to free zinc from the ore. But this important industrial art is not one for which we owe much to China — a country that all geographies truly describe as now half-civilized and utterly ignorant of modern science.

Lesson XIX.

Forests.

What is a forest? A tract of land covered with trees. Forests are of the greatest importance to a country. They aid in keeping the soil moist. They enrich the ground. They afford shelter to game birds and beasts of the chase. The trees furnish timber and fuel. Many gums, dyes, drugs, and articles of food are forest products.

Trees, like other plants, need, for different kinds, different degrees of light, heat, moisture,

and elevation above the sea. The same trees seem to require similar climates, but similar climates do not always produce the same species of trees.

Entire forests are, in many cases, made up of one kind of tree. Districts, hundreds of miles square, entirely covered with birch-trees, may be found in Lapland ; and in Canada there are millions of acres overspread with the pine.

In our Middle States the woods contain, generally, trees of various species. A great botanist, rambling in a forest not far from Rochester, N.Y., noted forty-one kinds of timber trees in a mile's walk.

A moderate extent of forest helps agriculture greatly. The Mediterranean borders of Spain, France, Italy, Greece, and Turkey, once produced, every year, immense quantities of grain. Now, the southern portions of those countries are often parched with droughts, and yield but scanty harvests. The woods which once clothed the mountain slopes have been cut off. Thousands of springs that formerly existed under forest shelter have now wholly disappeared.

One of the causes of the terrible famines which occur so frequently in India and China is the senseless removal of the timber on hillsides, where the trees used to hold, by means of the

earth between their matted roots, a large part of the rainfall. The rain-water now runs quickly off to the sea, and in summer the land is as dry as dust.

The science of forestry constitutes a separate branch of education in several European countries. In Germany the time for sawing down timber trees is decided upon by officers of the Government.

Whenever a tree is felled, a forest ranger carefully plants in place of it a slip of the same species.

By pursuing this prudent plan, the German nation has saved its woods, and has thereby greatly assisted the farmers, because the trees have preserved the springs from drying up.

The continued replanting has had the further good effect of preventing timber from becoming scarce, and therefore costly. Germany's 30,000,000 acres of forest have all been surveyed and divided into blocks, and the value of each block has been estimated and recorded. The government has printed, for the guidance of its forest officials, accurate maps of each wooded district.

Not a tree can be cut down in certain districts without the government's permission. A tree felled in any block is made the subject of a special report by an overseer.

The first settlers in our own country found here forests of enormous extent — large enough, apparently, to satisfy all the timber needs of the population for centuries to come.

Yet to-day it is doubtful whether any State, except, perhaps, Washington, has more woodland than it ought to preserve forever sacred from ax and saw. Several States, densely wooded not many years ago, are now obliged to draw from Canada their supplies of pine, oak, ash, and hemlock lumber.

Every year forest fires are allowed, through gross carelessness, to burn up millions of cubic feet of valuable timber. Every year the reckless destruction of our noble woods goes on with increasing rapidity.

When we reflect that the cutting down of our hillside forests will result in dangerous spring floods and in summer droughts, how wise seems the German law which commands the planting of a young tree for every old one felled!

It is to be remembered, indeed, that a forest is not a mine. To get good crops of timber, it is necessary, year by year, to cut down the large trees, in order that the small ones may have room to grow. But such cutting ought to be done here as carefully as it is done in Germany.

The ax and the saw should be to our forests

what the grain-cradle and the reaper are to our wheat-fields and bonanza farms. We should harvest our timber as if it were corn, cutting it when it is ripe, but never failing to take pains to secure another crop next year.

Valuable indeed is our harvest of forest products. In 1890 that harvest was estimated to be worth $800,000,000 — seven times the value of the whole world's yield of gold for the same year!

Russia has about 400,000,000 acres covered with trees. In that country, outside the large cities, nearly all the buildings are made of wood.

Astrakhan, the chief port on the Caspian Sea, obtains its fuel in a singular manner. About 100,000 vessels, built of logs and loaded with North Russia products, are annually sailed down the Volga; and when these strange ships reach Astrakhan, which is situated near the mouth of the river, they are broken up for firewood.

Resin, turpentine, and tar are yielded in immense quantities by the vast pine forests covering the northern provinces.

The most valuable forests on the globe are in Brazil. For 1,200 miles the Amazon flows through a dense forest which is from 600 to 800 miles broad.

At the World's Exposition, held in Paris in 1889, Brazil exhibited 300 different kinds of wood,

most of them being of great commercial value. Caoutchouc (india-rubber), dye-stuffs, cocoa, maté, mahogany, sago, annatto, sarsaparilla, rosewood, Peruvian bark (from which quinine is made), vanilla, and cinnamon may be mentioned as some of the products of Brazilian forests.

The richness of tropical America's vegetation is well known. The West Indies and Central America furnish us with many rare and costly woods. Mahogany is plentiful in those regions. Why, then, should not this beautiful wood be cheaper? Because, in the districts where it grows, laborers are scarce, and there is no convenient mode of transporting the logs to the seaboard.

Unlike the common furniture timbers, mahogany has not long been known to civilization. About the beginning of the eighteenth century, a few planks of the wood were sent to a gentleman in London by his brother, a resident of Jamaica.

The Londoner was having a house built, and he told the carpenters to use the planks for stair-railings. The new wood proved to be so hard that it spoiled the workmen's saws. Such "outlandish" lumber could not be cut, the carpenters declared.

A joiner, named Wollaston, was then requested to make a candle-box from one of the planks. Though he broke several tools, he persevered, and

finally made the box. When polished, it was, to English eyes, so handsome that it became an object of public curiosity.

Mahogany sprang at once into popular favor; and, ever since, the wood has been an unfailing source of wealth to the tropical regions of the western hemisphere.

The wax-palm, a most valuable tree, flourishes in the northern half of South America. Brazil's production of palm wax is worth over a million dollars a year. Colombia exports large quantities, also, of this curious vegetal substance, which finds many uses in the industrial arts.

In the island continent, Australia, the total forest area is small. The leaves of many species of trees there hang vertically — that is, the edges of the leaves are turned towards the ground.

The foliage of such trees affords, of course, but slight protection against the burning rays of an Australian January sun. Throughout the southern hemisphere the weather is hot during our winter months, and, therefore, in Southern Australia Christmas comes in summer! Do you remember your geography's explanation of this singular exchange of seasons?

A great forest is a wonderful sight. No one who has never been in the depths of some very old

woods can imagine the denseness of the fallen timber.

Dead trees lie heaped around, forming barriers, perhaps eight or ten feet high; trees recently blown down block the view with walls of earth held by their twisted roots; trunks, moss-covered and rotted, are to be seen everywhere.

Dry, barkless trunks, and trunks still green, prostrate or propped up at various angles — logs in every stage of decay meet the bewildered gaze. The swampy ground is green with vines having stems and leaves thickly set with thorns that can pierce the strongest cloth.

In the south of Indian Territory, there is a forest covering 800 square miles. The railroad track through it seems to be walled in, on both sides, by tall, somber trees, each of them over a hundred feet high apparently, and having foliage so thick that the eye can penetrate only a few feet into its dark recesses.

Human abodes are passed at long intervals only. Once in a while the traveler, looking from a window of his car, may catch a glimpse of a clearing made by some lonely backwoodsman.

Hunters that have explored this timbered wilderness tell us that many of the trees are wreathed with twining mosses of the brightest colors.

Numerous trees seem to be standing on stilts.

Roots, springing far out of the soil, leave between them openings so large that a man can walk through them upright. This remarkable fact is easily explained. The trees supported on such roots have grown up over decaying trunks of fallen giants of their kind.

Tree-felling in such a forest differs widely from the wholesale lumbering carried on in Oregon, Washington, Minnesota, and Maine. In the dense woods of Indian Territory, a gang of lumberers comprises only a few men.

A tree hewed down must be cut by hand into logs. A pit is dug as close as possible to the fallen tree. Then, by ropes or chains, it is pulled half-way over the pit, horses furnishing the motive power. The limbs, being useless for lumber, are lopped off first. One sawyer then stands on the trunk, another descends into the pit, and both set to work with a long, two-handled saw.

In the States mentioned and in Canada, lumber-cutting is done in steam saw-mills — monster plank-making factories, to which logs are brought from various distances.

Each owner of a saw-mill engages companies of lumberers to work for him by the season. In some localities those workers are hired, each for a certain sum a month : in other places they are paid according to the amount of timber that they cut.

A leader is assigned to each band of loggers, and, late in the fall, they start off for the woods. As the logs must be floated to their destination, the saw-mill, the "boss" pitches the camp for his men as near as possible to a stream having suitable timber along its banks.

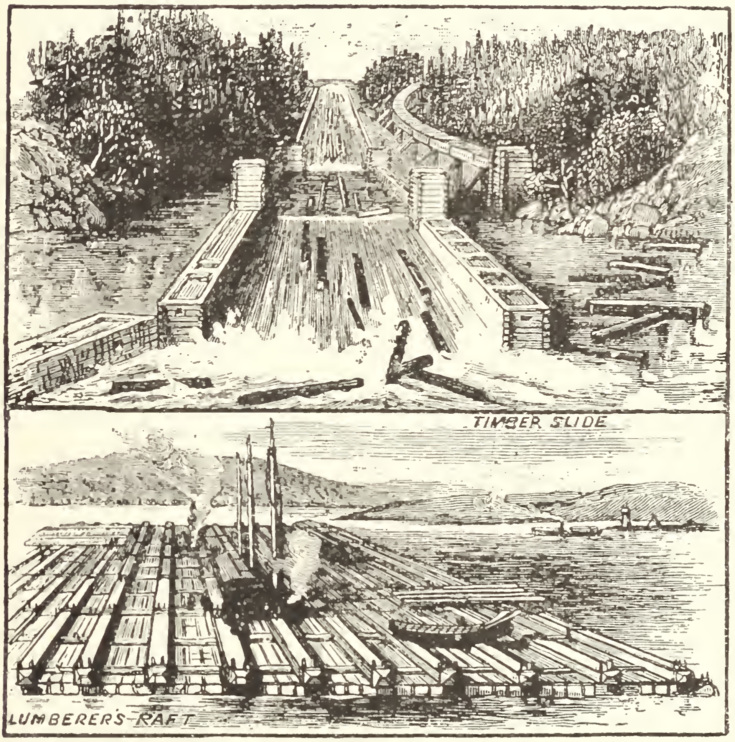
It is no longer an easy task to find large trees in goodly numbers, growing beside rivers; and nowadays lumber-camps are located often miles away from their chutes, or slides, down which the logs slide into the water.

A chute is made generally of logs placed lengthwise, and braced together beneath. The sides are composed of heavy planks, spiked to posts. Near Clifton, Oregon, is to be seen the world's longest chute. It is almost three-quarters of a mile in length, and cost $60,000. The floor is protected with railroad iron.

A log shoots from the top down to the river in twenty seconds. So great is the force with which the flying logs strike the water that spray is often thrown to a height of 200 feet.

Shanties of rough boards are hastily erected for men and horses; and then, with the dawn of the first morning in camp, lumbering begins in earnest. The best trees are selected by the boss, who chalks a death-warrant — a simple X — on each of them.

The ax proved to be too slow a tree-feller to suit the energetic lumbermen of our great Northwest, and timber is now cut down by sawing. Sometimes the saws are operated by steam-engines



Timber Chute and Raft.

that have been carried to the woods in numbered sections, and there put together.

When the lumbering season is over, and the ice on the rivers has been broken up by the rays of the spring sun, the logs are slid down the chutes,

and are bound, with chains, into rafts. These are then guided down-stream to the saw-mills.

It does not take long to turn the timber into lumber. Giant circular saws, each one twenty-four feet in circumference and revolving 500 times a minute, "break" the logs into the required lengths. The sections of timber are then cut by gang-saws into thin boards, or into planks, joists, or other pieces of lumber.

A gang-saw consists of a number of straight saws, set in a frame. The largest gang-saws have twelve saw-blades apiece, and can change logs into planks with amazing quickness. The blades can be placed as close together as may be desired.

Gang-saws are of great benefit to mankind, because they help to render lumber cheap.

If planks, boards, scantlings, joists, sills, beams, and other articles of saw-mill production, had now to be sawed out by hand, the use of lumber would almost cease, and millions of workmen would be thrown out of employment. As we are young Americans, we are glad to learn that for those useful and ingenious lumber-working machines the world is indebted to American energy and brain.

Lesson XX.

Yellow Treasure.

Gold is found in nearly all parts of the world. The metal often occurs in lumps, or nuggets, on the surface of the ground, and must have attracted attention at a very early age of man's history. On account of its beautiful color and luster, gold has been used for ornaments since the dawn of civilization.

The Old Testament tells us that when Abraham's man-servant met Rebecca at the fountain of Nahor he gave the damsel a "golden earring of half a shekel weight, and two bracelets for her hands of ten shekels weight of gold." Those trinkets were the first ones of which we have any written record.

Ancient temples were adorned with thin sheets of gold, and idols were often made of the same precious substance. The image of the god Belus was seated on a golden throne in the vast national temple in Babylon ; Apollo's statue at Delphi, in Greece, was made of gold ; and the colossal figure of the chief of the Greek gods, Zeus, carved of ivory, richly inlaid with gold, was a sacred object in the largest temple in Athens.

This statue was, however, less remarkable for its costly materials than for the faultless beauty of its workmanship. The sculptor was Phidias, the most gifted artist of ancient Greece.

We must not fall into the mistake of supposing that in the old pagan times all men bowed in fear before their hand-made gods. In a war waged by Rome against the kingdom of Parthia, in Asia Minor, a large golden statue of the Parthian goddess, Anaitis, was pulled out of its niche in a temple dedicated to her, and was carried off by some Roman soldiers.

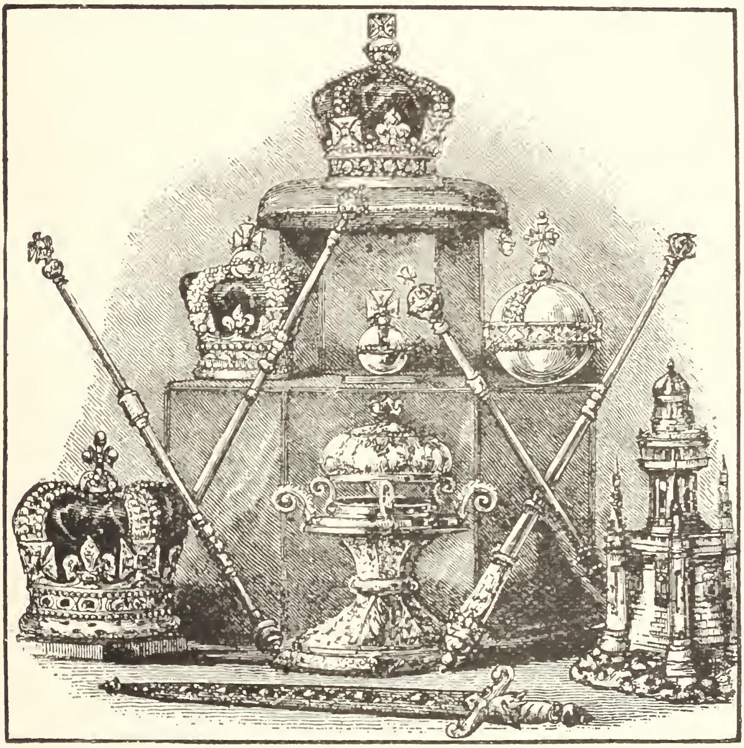
The Roman Emperor, Augustus, dining one day with an old veteran of that war, asked him whether it was true that the man who first laid violent hands on the statue had been instantly stricken blind and dumb, and had died in a few minutes.

"I myself am that man," replied the host, smiling. "Your Majesty's plate was molded from the head of that very statue!"

The wealth of sovereigns was estimated by the stores of gold which they possessed rather than by the extent of their domains. As conquered nations were stripped of their wealth by their victorious foes, the treasures amassed by some powerful despots amounted to fabulous sums.

The tons of gold and silver owned by Crœsus,

the richest monarch of antiquity, fell into the hands of his vanquisher, Cyrus, king of Persia. To those treasures, Cyrus's son, Cambyses, added the gold of Egypt; and a third Persian ruler,



Royal Insignia of Gold.

Darius, subdued several East India nations, and piled their golden spoils also in his palace vaults.

Thus, the larger part of the world's gold was, by the fortune of war, brought to Persia's ancient capital, Persepolis. Alexander the Great captured

this city, and removed to Susa the hoarded riches of the three Persian conquerors. 10,000 mules and 500 camels were needed to transport the gold and silver.

Rome, the mistress of the world, seized the treasures of Carthage and Egypt, of Asia Minor and Greece, of the countries watered by the Danube, of Gaul (modern France) and Spain. In the reign of Tiberius Cæsar, the public treasure-vaults contained 2,000,000 pounds of gold!

As the power of the Cæsars waned, the gold began to flow away from the great capital on the Tiber to the new cities springing up in the kingdoms which Goths, Vandals, and Huns were rearing on the ruins of the Western Roman Empire.

But a considerable part of Rome's riches found its way to Constantinople. That city was the Eastern Roman Empire's capital till it was stormed by the Turks in the year 1453. Then the remnant of the gold torn, at various times, from various vanquished peoples, fell into the possession of the victorious Turks, themselves robbers from Central Asia.

The date at which gold was first coined is unknown. The oldest gold coin that has come down to our own times is to be seen in the Royal Museum in Vienna, Austria, and was minted 700 B.C., at Cyzicus, a city of Mysia, a country of Asia Minor

at that far-off period. The next gold coin in point of age is Persian, and was struck, probably, in the fourth century before Christ.

According to a celebrated Latin writer, Pliny, the first coining of gold by the Romans took place in the year 547 after the founding of Rome. One of the Khalifs who lived in the famous city of Bagdad set up a mint there, and coined large amounts of both gold and silver. Have you ever read of the wise sultan, Haroun-al-Raschid, who, disguised, used to walk about Bagdad in order to learn his people's needs?

Gold money was used in Spain by the Visigoths who overran that country in the last days of the Roman Empire. Venice, in 1290, and, later on, Florence and Bohemia, struck gold coins. The Italian countries obtained their gold by trading with North Africa and the more distant East. The gold mines of Bohemia furnished the metal for the money of that kingdom.

Since the 13th century, the use of coined gold has been steadily increasing with the progress of trade and civilization. Yet even now, in portions of Asia and Africa, gold is not stamped, but is weighed, and is used thus in its native condition as a medium of exchange, just as it was employed (without coining) in the times of Abraham and Jacob.

Where did the nations which flourished before the Christian era get their gold? The chief sources of the ancient world's supply of this precious metal were India, the Caucasus district, Arabia, and Africa. Some historians think that the Por-

Gold-working in the Middle Ages.

tuguese territory of Sofala, in south-eastern Africa, was, 3,000 years ago, known by the name of Ophir — that ancient mysterious land, so renowned for the yellow treasure in the days of the wisest of the Hebrew kings.

For centuries the richest gold-bearing country in Europe was Spain. It yielded tons of gold to the Carthaginians, to the Romans, to the Visi-

goths, and, at a later period, to the Moors. During the Middle Ages Bohemia was famous for its gold, and the accounts of the early workings of its mines remind us of the descriptions of the scenes which our own century has witnessed in California, Australia, and South Africa.

A new epoch in the history of gold began with the discovery of America. By fraud and murder, the Spaniards got possession of the treasures of Montezuma, the ruler of Mexico, and also of the riches of Peru's last native monarch, or Inca as his subjects called him. In a hundred years from the death of Columbus, Spain took out of American mines more gold and silver than Europe had gathered from the fall of the Roman Empire to the beginning of the 15th century.

This New World treasure was obtained at the appalling cost of the lives of millions of peaceful Indians. The Caribs of the West Indies, the Aztecs of Mexico, and the Guaranis of South America were forced to wear out their lives in underground darkness, toiling to enrich their cruel masters.

But Spain paid dearly for her Western spoils. Her thirst for the precious metals caused her to neglect the real sources of national riches and power — agriculture, manufactures, and commerce. She could not keep an ounce of the thousands

of tons of gold and silver which she had wrung from the labor of the wretched slaves in her New World mines. Her metallic wealth had to be poured into other countries in payment for the necessaries of life. She rapidly declined from her position at the head of the European nations, and she has since been only a second-rate power.

In 1836, rich deposits of gold-bearing sands were discovered in southern Siberia. Mines hurriedly opened in the northern side of the Altai mountain range soon raised Siberia to the rank of the first gold-producing country in the world.

But the fame of those mines was, in 1848, eclipsed by the eventful discovery of the California placers, — dried-up river-beds with sands rich in gold.

A workman, named James Marshall, noticed some large grains of a bright yellow metal in a mill-race near the site of the present town of Coloma. The metal proved to be gold, and the news of its discovery soon spread over the world.

An immense number of gold-seekers poured into the Territory. Adventurers from every State in the Union, from every country in Europe, from the Hawaiian Islands, from Australia, from Asia, came hurrying over the Rocky Mountains, or through Mexico, or around Cape Horn, or across the Isthmus of Panama, or over the Pacific — all

eager to seize fortune at one bound, and willing to face any danger in the attempt.

In a few years California numbered more than half a million inhabitants, and San Francisco rose, from an obscure hamlet, to the distinction of being one of the world's great commercial cities.

An eminent English geologist, noticing, in 1850, the close resemblance between the Australian rocks and the gold-yielding quartz of the Ural Mountains, advised some miners of Cornwall, England, to go to south-eastern Australia, and to search there for gold.

This advice having become known at Sydney, through the newspapers, several miners began to prospect for the yellow metal. One of them, who had recently arrived from the California gold-diggings, was successful in the highest degree.

He discovered rich gold deposits near Bathurst, New South Wales, in 1851. Shortly afterwards a negro shepherd found a quartz block containing sixty pounds of gold, and brought it to his employer. The black man received the splendid reward of a suit of old clothes!

The whole district at once became the scene of the most active research. Another block of quartz, obtained by an hour's labor, was sold at public auction for £1,000. Half a dozen similar prizes were unearthed within the bounds of New South

Wales; but the richest of these finds was soon far surpassed by some wonderful nuggets of the precious metal revealed, the same year, at Ballarat, in the neighboring province of Victoria.

On receipt of the news of the existence of this new gold-field, the people of Melbourne and Geelong deserted their homes and rushed to Balaralt. Yet but few remained there long. Fresh reports of newly discovered mines of extraordinary richness drew crowds of diggers from one place to another.

Twenty thousand people, meeting with fair success at their daily labor of gold-washing, would abandon their claims, and rush to the most lately discovered diggings. Laborers quickly became of more importance than employers, because every man was entitled to mark out a claim that no one else had taken, and thereon to work for himself.

The miners were of all nationalities. Englishmen, Italians, and Spanish-Americans toiled side by side. Chinese came in great numbers. They were very much disliked by the white miners, and the government taxed each Chinaman for the privilege of entering the colony.

To escape payment of the tax, one ship-load of Chinese landed in South Australia, and stole over the country towards Victoria. Near one of their resting-places, they found, under a cliff, a small

hollow filled with grains of gold. In an hour, the fortunate Chinamen had collected 3,000 ounces of this coveted metal!

The locality for miles round about contained gold deposits of marvelous richness, and in two weeks 60,000 persons had gathered there. A town sprang into existence, as if by magic. Warehouses, stores, hotels, and dwellings were to be seen in a region that, a month before, had been a desert. In the short space of four weeks, the desire for gold changed a tract of rocky soil into a busy city.

The wonderful discoveries in California and Australia having made gold the absorbing topic of the day, men sought far and eagerly for new gold-diggings. British Columbia, New Zealand, Borneo, Mexico, Peru, Bolivia, China, Burma, and Russia are some of the other gold-yielding lands of the present time.

What country is now first in the production of gold? The United States. What country is second? Either Australia or the Russian Empire. It is not known with certainty how much of the prized yellow metal is mined yearly in the vast dominions of the Czar. In 1890, our own country yielded nearly $33,000,000 worth of gold; and the gold product of the whole world for that year was about $118,000,000.

The richest gold mine ever known was dis-

covered in Queensland, Australia, in 1888. The mine is in a hill, called Mt. Morgan, and the metal obtained from it is nearly pure. Men of science tell us that this gold was dissolved, millions of years ago, by some boiling-hot liquid — perhaps some kind of acid — and brought up from deposits far below the surface.

The Queensland government sold the land on which Mt. Morgan is situated, together with a large tract around it, for one shilling an acre to an English settler; and he disposed of the property at one pound sterling an acre, thereby making a very good bargain, he thought, no doubt. The owners of the land took from it, in 1891, gold enough to coin into $6,000,000!

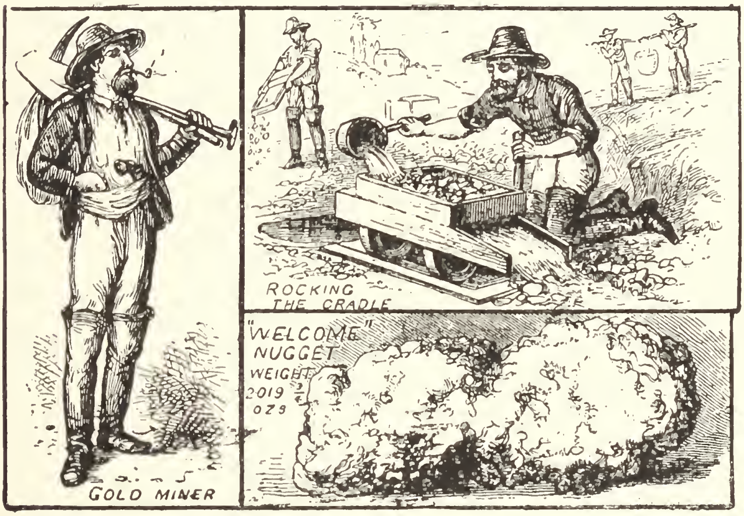
We all have read that our Rocky Mountain States produce gold, but what pupil in this class has learned that this yellow metal is mined in North Carolina? Yet from that State's soil gold to the value of $11,000,000 has been taken within the last half-century.

As our population becomes denser, new mines will doubtless be opened in many States not now classed among the gold-yielding ones.

It was not till 1886 that the yellow treasure was found in large quantities —

> "Where Afric's sunny fountains
> Roll down their golden sand."

The Transvaal contains immense deposits of coal, iron, copper, silver, and gold. That country's output of gold from 1885 to 1892 was estimated at $55,000,000. Yet the appliances used until recently were so rude in construction that they



Gold Washing.

probably failed to separate more than half the metal from the gravel washed.

The methods of carrying on gold-seeking operations vary, of course, according to the nature of the deposit which is worked, and the resources of the miner.

The simplest method — the same one that was most practiced in the early days of gold-hunting in California and Australia — consists in throwing

shovelfuls of the soil into a *cradle* — a section of tree-trunk hollowed out and provided with cleats on the bottom.

The larger end of the cradle has a box into which the earth is put. Water is then added, and the cradle is rocked, so that the gravel and earth may be washed away, leaving behind the larger stones and the gold. Any grains of the metal carried out of the box will be stopped by the cleats, as these cross the other part of the cradle's floor.

Machines for gold-washing by horse-power are now in use in the Transvaal. In some States of our own country, and in New Zealand and Australia, a mode of washing gold-bearing earth by water carried through rubber hose is employed. A sloping sluice is built of planks, the bottom being crossed by narrow wooden bars.

The water must come from a reservoir higher than the sluice; and the higher the reservoir the greater is the force with which the jet strikes the bank of earth.

Three men, working a strong jet of water, can wear down the material of a hill into a sluice much more rapidly than a hundred men could do the work with shovels or spades.

Fatal accidents are not rare. Immense masses of earth often fall suddenly, and bury under them

the men at work below. The force of the jet is itself a danger, loss of life being of frequent occurrence from this source.

A stream of water, falling from a height of 375 feet, and conveyed through a pipe eight inches in diameter, will roll a bowlder, weighing a ton, from fifty to a hundred feet, according to the nature of the ground.

The force of such a stream is terrific. If a man, 200 feet away from the nozzle of the pipe, were struck by the jet, he would be killed instantly. At 400 feet from the nozzle, a tree against which such a column of water is directed will be stripped of its bark in five seconds.

Such a stream, turned on a gravel-bank, will hollow great caves in it, causing tons of earth and gravel to fall every few minutes into the sluice beneath. The amount of material which can be thus removed in a short time is almost incredible.

During the year in which this mode of gold-washing was most extensively employed in California, there were carried away daily about 40,000,000 cubic yards of gravelly soil in one district alone — the district watered by the Yuba, Feather, Bear, and American rivers. This quantity of material would make a hill 1,500 feet long, 1,200 feet wide, and 600 feet high.

Some States have passed laws forbidding the

use of the water-jet method, which is commonly called the *hydraulic* method. It was soon perceived that the miners washed down through their sluices vast masses of sand and gravel, which spread over the rich riverside lands, and rendered them useless for farms or gardens. As we can live without gold but not without food, I think that such laws are wise laws. Do you not agree with me?

In the very earliest writings that have come down to us, gold is mentioned as an object of men's search and as an article of extreme value. The importance which it possessed in ancient times has certainly not lessened to-day. Yet though it is the most generally sought product of the globe's crust, gold is much more widely distributed than platinum, nickel, and several other metals.

The amount of the world's yearly gold product has been decreasing since 1863. The immense placer deposits of many regions have been exhausted. The extraction of vein-gold from its hiding-places in that exceedingly hard rock, quartz, is a slower and much more expensive operation than the washing process. The richest California deposits were placer fields.

But gold-mining nowadays means a great deal more than mere gold-digging, and the miner whose

outfit comprises only a pick, shovel, and cradle, is no longer to be seen in the United States.

Our supply of the yellow treasure is now obtained generally by blasting granite mountains, by powdering hard rock by means of heavy hammers (called *stamps*), or by crushing it between huge steel rollers, and by the use of tons of that costly metal, mercury, or quicksilver.

Large sums of money must often be spent in making preparations to work a deposit of gold. An Idaho company, engaged in placer mining, was obliged, in 1891, to dig a wide ditch, twenty miles long, in order to get water enough to carry on operations. 6,000,000 feet of lumber were used in constructing this little canal, and its cost was about $2,000,000.

Gold never occurs absolutely pure. Some silver is always mixed with it in both vein-deposits and placers. Occasionally gold is found in the ores of copper, iron, nickel, lead, and zinc; but such ores never contain more than a small per cent of the more valuable metal.

In no period of human history has gold been more eagerly sought in all parts of the globe than in this 19th century of ours. Enormous quantities of the yellow treasure have been taken from the earth during the past fifty years, and have been added to the hoards of ages. Coined into that

measurer of wealth which we call money, gold has, doubtless, been of much benefit to mankind.

The world has grown too large to transact business by bartering, the mode in which the savages of the Stone Age traded.

If the *love* of money is the root of all evil, let us remember that the proper *use* of money may be productive of much good. In other words, it is far better "to get gold and share it, than to get gold and wear it." I hope that every pupil in this school knows how much more blessed it is to give than to receive.

Let us look for a moment at the picture on page 219. We see an engraving of the largest lump of gold ever found — the Welcome Nugget. This prize was discovered, in 1858, near Ballarat, Australia. It was sold for £10,500, a sum about equal to $51,000. How much good might have been done with that lump of metal!

In placers, which, you recollect, were once beds of rivers, gold occurs in grains. In some of the Austrian gold mines in the Carpathian Mountains, the metal occasionally assumes beautiful leaf-like forms. These bring high prices among collectors of curios for mineral cabinets.

The peasants of Northern Italy, Hungary, Thibet, and Brazil, have an ingenious method of collecting metallic wealth from a stream flowing

over gold-bearing sands. Sheepskins, wool-covered, are pegged down on the bed of some brook whose gravel yields gold, and are allowed to remain there till a quantity of gold, in grains, has become entangled in the wool.

The story of the Greek warriors who sailed away from home in quest of the famous Golden Fleece probably had its origin in an attempt to capture by force some sheepskin that, fastened on some river-bed, had caught an unusually large amount of gold.

In malleability, gold is the first of the metals — that is, it can be beaten out thinner than any other metal. The surface of any given cube of gold may be extended, by the hammer, 310,000 times. A cubic inch of this metal can therefore be beaten out into a sheet containing about eight square rods!

A bit of gold weighing only a grain — a bit smaller than the head of an ordinary pin — can be drawn out into a wire 500 feet in length. Eight ounces of this remarkable metal would gild a silver wire long enough to reach entirely around the globe!

Any store dealing in gilders' supplies can sell you a book of gold-leaf. 700 leaves of gold from that book, placing those leaves one on another, would not make a pile equal in thickness to *one*

leaf of this reading-book! Is not gold a truly wonderful metal? Yet which is the more useful to mankind, gold or iron?

Lesson XXI.

Silver.

Silver must have been known long before any account of its first discovery was recorded by historians. An ancient Greek author, named Diodorus, says that some shepherds set fire to a forest on one of the Pyrenees Mountains, and that streams of molten silver flowed for several feet down the side.

The cunning Phœnician merchants, trading with the savages of that portion of Spain, bought all the metal for a handful of glass beads!

Among the nations of antiquity, silver was in common use, both for ornamental purposes and as a means of exchanging goods or other property.

We learn from the Old Testament, that Abraham paid to Ephron the Hittite "four hundred shekels of silver, current money with the merchant," for the field of Machpelah. Indeed, long before the patriarch's time, silver must have circulated among the traders of the East.

In the reign of Augustus Cæsar, Emperor of Rome, the tables of many of his wealthy subjects were loaded with solid silver dishes, weighing 500 pounds apiece. Silver statues were common objects of art in the hallways of Roman palaces.

The oldest silver mines of which we have any record were situated in the mountainous parts of Chaldæa.

The history of ancient Greece owes some of its brightest pages to a silver mine that belonged to the State. The profits of this mine used to be divided among the citizens of Athens, until a wise and able statesman, Themistocles, persuaded the general assembly of the people to apply the revenues of the mine to the building of several ships of war. With these vessels the Greeks won the great naval victory of Salamis, and inflicted thereby a crushing blow on the Persian enemies of their native land.

After the fall of the Roman Empire, the neglected mines of the East, of North Africa, of Spain, and of Hungary, ceased to be the sources from which silver flowed out to the world. Tons of the metal gathered during the ages of civilization were buried in the ruins of cities destroyed by fire, or were scattered among the hordes of barbarians who overran southern Europe.

The precious metals became rarer, and their

value increased, till, in the Middle Ages, Germany began to open a new era in mining, and to take the lead among the silver-producing countries of the globe. Later on, silver was discovered in the mountain ranges of Austria and Norway. Many of the deposits of the white metal in these countries proved to be of great richness, and yielded not only large quantities of ore but also several very large nuggets of pure silver.

A lump of silver ore weighing 560 pounds was found at Kongsberg, Norway, in 1666, and was sent, as a curiosity, to the great national museum in Copenhagen, Denmark, where it may still be seen. The mine was worked constantly for 168 years afterwards, and then there was dug out a block of ore that tipped the scales at 750 pounds, troy weight.

But the largest block of silver ore ever known was discovered near Schneeberg, Saxony, in the year 1477. This huge nugget was about twenty-one feet long and eleven feet wide.

When Albrecht, Duke of Saxony at that time, heard of the finding of this splendid prize, he visited the mine wherein it was discovered, and had his dinner served to him on the block. At the end of his repast he said: "My august master, the Emperor Frederic, is very wealthy and powerful, but he never dined from a table as valu-

able as this one." The smelting of this wonderful nugget produced 40,000 pounds of pure silver!

Though native silver is found in many localities, yet our chief sources of the precious white metal are those ores in which silver is found combined with other substances. A considerable quantity is obtained from galena, or lead ore, a mineral that generally contains a small per cent of silver.

Austria, Germany, and Russia are the chief silver-yielding countries of Europe.

The exceedingly rich silver mines of Mexico seem to have been worked by the Aztecs before the conquest of that country by the Spaniards. Those mines still yield large incomes to the owners. The most valuable lode was discovered in 1760, by a young Spanish trader named Obregon, who lived in Guanajuato, then a mere hamlet.

Some friends lent him money to work the mine. But it was difficult to reach the ore, and one by one his helpers withdrew from the enterprise. Obregon alone did not despair. At length his perseverance was rewarded. In 1771 the lode began to yield ore in paying quantities. For thirty-five years about $3,000,000 worth of silver was annually taken out of this famous mine.

Guanajuato grew in ten years into a thriving city. It is built in a narrow valley inclosed by mountains whose steep sides are cut into terraces,

rising above one another. On these the houses are erected, and the contrast afforded by the magnificent abodes of the wealthy mine-owners and the wretched huts of their workmen adds to the singular appearance of the place.

The Mexican miner could live much more comfortably if he had habits of thrift and temperance and industry. He squanders his hard-earned wages in the most wasteful manner, and seldom returns to his work till his last dollar is gone.

The mine-owners of Mexico are beginning to introduce improved machinery, and to use modern methods of extracting silver from the ore. Steam-pumps are employed in place of raw-hide bags, to draw the water out of the mines, and ore-washing machinery, brought from California, separates the metal from the dross.

Thousands of tons of various ores of silver are, however, still exported to be refined in other countries — principally in England and in the United States. In 1891 there were in Mexico 550 silver mines, and from them came about one-fifth of the world's silver yield for that year.

Have you ever heard of Potosi, the mountain of silver? One day, in the year 1545, an Indian, pursuing a deer on the side of a Bolivian mountain, took hold of a shrub. Its roots gave way, and disclosed to view a mass of silver. This accident

brought about the first discovery of the riches which have made Potosi another name for wealth.

The Indian wisely said nothing about his good fortune, and repeatedly visited the mine, bring-

A Road in the Andes Mountains.

ing away on each visit as much silver as he could carry. Finally his improved circumstances aroused the suspicions of one of his own tribe.

The discoverer of the mine was secretly followed to it by his envious fellow-countryman, who

obliged the former to accept him as a partner. Unluckily for both Indians a quarrel ensued, and the second Indian betrayed to his master, a Spaniard, the location of the mine.

The master's extraordinary success in drawing, every year, an immense fortune from this mine soon became known throughout the civilized world. Within a few years a city of 100,000 inhabitants rose on the desert tableland, despite the wintry nature of the climate and the high cost of living. All the necessaries of life had to be brought a long distance over dangerous mountain roads. You may judge from the picture on the preceding page that a journey over an Andean mountain path must be full of peril to the traveler from the United States.

If, however, food and clothing were dear, the citizens of Potosi had the means needed to supply all reasonable wants. The riches dug out of the depths of the mountain there seem to belong rather to the realm of fairy-land than to this prosy world of ours. That one mountain yielded, from 1545 to 1813, silver worth $1,300,000,000!

During the period of Potosi's greatest prosperity — from 1585 to 1606 — about 15,000 Guarani Indians labored daily in the mines. The red-men proved to be good miners. Their hardest task was to climb, with a back-load of 300 pounds of

ore, up a steep stairway consisting of a series of steps, roughly cut in joined logs, or in the solid rock. Yet the Indians would work steadily, as ore-carriers, for six hours at a time.

The muscular strength required to do such labor seems amazing to a visitor to the mine. Only once in a while is a white man found who can come up such a flight of stairs without stopping several times to rest, though he carries no load at all to increase the toil of climbing.

The ores were at first smelted in a very imperfect manner,—the one that the Spaniards learned from the natives. Alternate layers of ore and charcoal were put in clay ovens which were built, in the open air, on the upper half of the mountain, and, a fire being started in each one of them, the most of the metal was removed, in a few hours, from the earthy matters.

Travelers that visited Potosi in its early days have left us vivid descriptions of the magnificent scene presented, at night, by the 6,000 fires which blazed around the mountain's crest.

On the bleak tableland of western Peru is situated the famous mining town of Pasco. Its straggling streets and filthy lanes, swept by the freezing winds of the Andes, stretch over miles of rocky ground.

The coldness of the climate and the location

of the city, only a day's journey from the lovely, sun-warmed valleys at the base of the Andean mountain chain, prove that the treasure obtained

Peruvian Silver Mine.

from the mines must be great indeed to induce so large a population to settle in so desolate a spot.

Pasco's mines were discovered by an Indian shepherd who happened to light a fire on an out-cropping ledge of ore, and found silver among the embers. Though the mines have never been

worked in a thorough manner, yet immense quantities of the white metal have been taken from them annually for two hundred years.

Pasco is the highest town in the world, being 14,000 feet above the sea-level. If we should visit that city, we should find ourselves unable to walk twenty feet there without stopping to take breath, because the air is so rarefied.

About two centuries ago the most famous mine in Peru was the Salcedo lode, so called from the name of its owner. He learned of its existence from one of his Indian slaves.

The fame of Salcedo's wealth soon spread far and wide, and aroused the envy of the viceroy, or governor, of Peru. He sought to gain possession of the mine. Its good-natured and generous owner was beloved by the poor, oppressed Indians, and this fact the evil-minded viceroy made use of to accuse him of inciting the natives to throw off the Spanish yoke.

Salcedo was cast into a dungeon, and condemned to death by the judges of the province, who were merely creatures of the viceroy. While in prison, Salcedo begged the privilege of submitting his case to the high court of justice at Madrid, Spain, or of appealing to the mercy of the viceroy's master, the king. For either favor the unfortunate prisoner offered to give daily a five-pound bar of

silver, from the day on which the vessel bearing his lawyer left Callao till it returned.

If we remember that in those times a sea-voyage from Peru to Spain required from twelve to sixteen months, we may form some idea of Salcedo's wealth. The viceroy brutally refused the humble request, and straightway ordered the innocent man to be hanged.

But the viceroy's avarice and cruelty met with deserved punishment. When it became known that Salcedo could not be saved, his Indian friends destroyed the wooden steps descending into the mine, and so effectually hid the entrance that it remains undiscovered even to the present day. After performing this work of justice, the Indians dispersed, and neither promises of great rewards nor the most horrible tortures could draw the secret from those who were run down and captured.

Since 1862 the United States has produced more silver yearly than any other country in the world. The richest mine ever worked in Mexico or South America would seem poor if compared with the Comstock lode, a vein of silver ore which yielded over $300,000,000 in twenty years! That marvelous deposit of metallic wealth is now exhausted.

The silver had mingled with it a small quantity of gold, and the vein of ore was followed down into the depths of the earth — down 3,400 feet. The

water which welled up through the floor of the deepest shaft was scalding hot. The miners were unable to work more than four hours daily. Yet it seems to me that any one of those men who labored in steaming, poorly lighted caverns, almost three-quarters of a mile underground, would have earned a day's wages, if he had worked only one hour. What is *your* opinion?

Colorado now stands first among our silver-producing States. Montana, Idaho, Utah, California, Arizona, and Washington have rich deposits of silver ore.

Let us visit a silver mine.

"All aboard!"

Our car is drawn by the swiftest locomotive ever used — the Imagination. A moment — and the train stops.

"All out for Silver Mine!" calls Fancy.

Yonder is the mining-camp — a collection of small houses built of planks. We notice a store containing groceries, dry goods, clothing, boots, hardware, and other merchandise.

"A queer little shop!" some one remarks as we pass a shanty whose front is plastered over with slips of pink or of yellow paper scrawled with Chinese letters. Within, we see a short, stout Chinaman engaged in washing clothes.

Those large buildings at the base of yonder low

hill are the works in which the silver ore is refined. We call at the office, and we get from the superintendent a pass, permitting us to visit the mine.

The little wooden structure on the top of this hill covers the opening of the shaft. About a minute of hard walking brings us inside the building. The sole occupant is a tall man, who nods slightly to us as we enter. We show him the pass, and he hands each of us a folding candlestick, a candle, and a box of matches. We step into the large, heavy wooden box, by means of which the miners descend to their scenes of daily labor.

"Ready?" queries the tall man.

"Yes."

Down the car sinks, and it passes through 600 feet of space before it stops. That gleam of light shooting through a side of the shaft, about half-way between top and bottom, comes from the outer world. In digging the shaft, a rich vein of silver ore had been struck, and followed up.

With the aid of their pick-axes and a few beams, four men worked their way from this underground darkness to daylight. They tunneled through to the outside of the hill, a distance of 300 feet. The vein yielded upwards of $50,000.

Some silver ore is placed in our hands, and it seems to us to be of no more value than common rock. We cannot detect even a trace of any kind

of metal. It is, however, 25-dollar ore — that is, ore of the value of $25 a ton.

The miners labor singly or in groups, we note. Some of the men are digging downwards, some are drilling openings in the sides of the mine, other men are working up towards the roof.

"They follow the seam of ore wherever it goes," explains the foreman.

Trolleys, each one about twice the size of a wheelbarrow, run along all the main levels, or passageways. A large box, termed a truck, receives at the shaft the ore from the trolleys. When filled, the truck is hauled up to the top of the shaft, and its contents are transferred to a freight car of the open-box kind.

A railroad track runs down from the mouth of the mine to the refining-works, and a loaded car descends by means of its own weight, pulling up at the same time an empty car.

Conversation with the miners is strictly forbidden. We look at them, as by the dim candlelight they hammer at the solid rock, and we observe that their faces are pale and grim. The workers in a silver mine have, however, absolute freedom from two great dangers that constantly threaten all coal-miners — fire-damp and choke-damp. Hence, safety lamps are not needed here.

Rough, however, as the miners look, they are

honest, brave, and very willing to help any one in trouble. Their unwritten law is the Golden Rule, "Do as you would be done by." This rule is good enough to be followed by even the minors now at school, is it not?

We return to the upper air in the box in which we came down.

If we should keep track of the ore in that car now running to the works, we should see the rocks pounded with seeming frenzy by iron stamps — machines (like hammers) that have heads and handles of iron, and that are raised and driven down by steam.

When the ore has been reduced to powder, it is passed through a sluice, whose floor is crossed with lines of mercury held back by cleats. The silver combines with the mercury, and forms an alloy. The earthy portion of the ore, called the "tailings," is carried away by the water flowing through the sluice.

Our own great country is first in the production of silver as well as of gold. In metallic wealth no other land can compare favorably with the United States. Our republic's yield of the precious metals has had no parallel in the history of any other land and may well excite the wonder and envy of Europe. The Roman Empire, at the zenith of its power, — Spain, when practically

the mistress of the Western Hemisphere, could not rival, in treasures of silver and gold, the United States of 1892.

Lesson XXII.

In Woods Abroad.

A TREE is a living thing, and feels a wound more readily than might at first be suspected. An animal tells us by its actions when it has been injured. We know the injuries done to trees only by the after effects, and these may not be evident for months.

People living in cities are well aware that it is very difficult to grow shade trees, owing to the ill-treatment these receive. Their coverings of bark are gnawed off by horses, or, if the trunks are protected by guards of wood or of iron, mischievous persons break off branches, or damage the trees in some other way.

How attractive a street lined with beautiful shade trees looks! Nor is the beauty of the trees their sole value. We should find that they are also useful, if we were near them on a hot summer day. Would it not be well for every

one of us to remember that a tree is something to be cared for and respected?

Hundreds of millions of feet of lumber are annually worked up into articles of furniture in Western Europe. Every year timber assumes a more prominent place in the list of Sweden's exports. Several towns on the western side of the Gulf of Bothnia now annually send many million feet of lumber to Great Britain, Germany, France, and other countries, including even distant Australia.

Part of this lumber consists of planks of various kinds of wood, but large numbers of doors, window-frames, blinds, and other manufactured articles are also exported. The amount of trade in these goods increases every year. The commerce in wood-pulp, a material from which a great deal of paper is made nowadays, has increased very much in recent times. Indeed, so many factories have lately been erected for manufacturing this wood-product that the price of the article has been lowered considerably.

Timber is cut in Sweden, as here, during the winter, and the logs are floated down the rivers in the spring, when the volume of water running seaward is increased by the melting of the ice and snow. In the seaports the logs are sawed into planks of various lengths. The lumber is then

piled up, and is left to dry. It is shipped away during the summer and autumn.

In the timber ports the lumber-carrying vessels usually anchor at some distance from the town, and the planks and manufactured articles of wood are taken out to them in large, covered boats, called lighters. It is wonderful to observe how little space is wasted in stowing the lumber in the holds of the big ships. Each captain loads his craft as heavily as possible. Often a vessel's safety is risked, and her crew's lives are endangered, for the sake of a few hundred extra pounds of freight.

Forests cover nearly half the surface of the northern portion of Sweden. They are chiefly of pine and fir. The government owns about 13,000 square miles of woodland, and in the management of this property sets an excellent example to private owners. Every year thousands of young trees are planted to fill up the wide gaps made in the ranks of the large trees by the timber cutters.

Gefle, the chief lumber-exporting town, is as pretty a little city as one could wish to see. The shores of its land-locked bay are covered with pine-trees, which protect a heavy undergrowth of ferns and moss.

This bay freezes over generally in December,

and the ice seldom disappears before May. Sleighs are employed in winter to carry the mail-bags over to the opposite shore of Finland, and merchants are compelled to use the same kind of vehicles for transporting articles of trade. Skating is resorted to by all classes as a necessity as well as a pastime.

Have you ever heard of ornaments growing on trees? No? Yet many kinds of seeds, fruit-stones, nuts, and beans are used for making necklaces, bracelets, and other articles employed for purposes of adornment. The vegetable ivory-nut of Brazil and the shell of the coco-nut are carved into various fancy articles, and can be highly polished.

The seeds of the West India necklace-tree are of a brilliant red color, and are often used as shirt-studs and sleeve-links. The kernels of the African soap-tree are pierced, and strung as necklaces and bracelets. A Hindustan plant bears beans that are fashioned into spoons, coin-cases, scent-bottles, and other small fancy articles.

The goldsmiths of India use certain little shining crimson seeds as weights. These seeds are obtained from a species of tree growing in that country, and their name in Arabic is *kirat*, the word from which our term "karat," or "carat," comes. This term is used by our goldsmiths too,

you remember, in describing the fineness of their gold jewelry.

Pure gold is twenty-four karats fine. Such gold is too soft to wear well, and therefore most articles of gold are hardened by the addition of copper or of silver.

Peach-stones are beautifully carved by the Chinese, and, set in gold, form exceedingly handsome brooches and bracelets. Large walnut-shells are frequently mounted with hinges, and are used as cases for lace handkerchiefs, for rings, and other small articles of ornament.

In Hindustan a peculiar nut, resembling our hickory nut, is employed by the manufacturers of fireworks to make cannon-crackers. A small hole having been drilled in the nut, the kernel is taken out, and powder is poured in; and, when it is fired, the shell bursts with a loud report.

The fruit of the talipot palm, an East India tree, is almost as hard as ivory, and is manufactured in Hindustan into chessmen, cups, perfume boxes and other ornaments, and in Europe into buttons, pen-holders, knife-handles, fine combs, and glove-stretchers.

You are now ready to believe, I trust, that many tree-products which you have heretofore regarded as of but little use may have considerable value in the world of trade and manufactures.

Where do the tallest trees in the world grow? In Australasia. Government surveyors measured, in Victoria, several gum-trees that were each about 500 feet high. Such trees must, of course, have very large trunks. Near Launceston, Tasmania, there was felled, in 1885, a giant gum-tree whose trunk had been hollowed out by decay. The enormous log was sawed in two near the first branch. Then, to test the size of the tree, fourteen men on horseback rode abreast through the trunk!

Gum-trees compose three-fifths of the forests of Australia and Tasmania. These trees, formerly thought of little value, have of late years been introduced into many countries where artificial tree-planting has been found necessary.

For many miles the track rails of the Central Pacific Railroad are guarded on both sides by rows of gum-trees, which have been planted to fend off snow-drifts. The timber of the gum-tree is strong, tough, and has great lasting power. The tree is rapid in growth, and one variety of it is of special value in marshy districts, because it destroys the germs that produce fever and ague.

The species of pine that yielded the resin which made amber has been long extinct, we have already learned; but a cousin of that tree, the kauri, flourishes bravely in far-off New Zealand.

It is a noble representative of forest life; for often a specimen of it is met with that measures forty feet in girth.

The kauri is a superb mast-timber tree; and kauri timber is exported in large quantities to Great Britain.

The tree exudes resin freely, and lumps of it, weighing, each, thirty or forty pounds, are often discovered at the bases of aged kauris. This resin, or gum, brings about $200 a ton, and thousands of tons of it are shipped yearly to Europe. It is used in making varnishes.

A large part of Africa is treeless and arid. The drought in the greater part of the Sahara Desert is so severe that no tree can resist it.

But some portions of the Dark Continent are rich in woods. In the north-eastern section of the Congo State the vegetation is very dense. Axes and heavy knives have to be used to clear a path. Stanley's company, marching from the Congo River to the Equatorial Province, in order to relieve Emin Pasha, spent 160 days, over five months, in passing in a direct line, through this forest region.

The only human beings that dwell in this vast wooded tract are the dwarfs that recent African explorers call Akkas. These human mites live mainly by hunting. Occasionally they procure

from the negro tribes east of them, some vegetable food in exchange for the skins of wild beasts.

The little black hunters are expert with the bow; and in their fights with ferocious animals they display a courage and an activity that would do credit to the spearmen of Masai-land, the most dreaded warriors in Africa.

To produce thick forests, an abundance of rain and heat is needed. Both are found in the interior of the Congo State and in north-western Brazil. In those regions the densest woods on the globe are to be seen.

The study of the vegetable kingdom will show us more wonders than the animal kingdom affords.

If we were in West Africa, we might cool ourselves under the shade of trees that were old when the infant Moses slept in his wicker cradle, hidden in the sedge of the Nile.

The African tree called the baobab lives to be thousands of years old. One specimen proved, on careful examination, to be more than 5,000 years of age!

This tree was ninety-eight feet in girth, and the spread of its branches was enormous. On account of the thick leafage of a baobab grove on Cape Verde, that tongue of land was given its name by some Portuguese sailors.

Oil palm-trees, trees that yield useful gums,

ebony, rosewood, and the shea-butter-tree are other forest products of western Africa.

Ashantee may be described as almost one continuous forest, composed of large trees, with creepers as strong as ropes stretching from one tree to another.

These mat together the foliage overhead, forming a green roof. Here and there are chinks, through which the sunshine falls in splashes of light on the ground. In such woods the traveler must make his way in a kind of twilight.

Should we not regard a tree as very valuable if it furnished us food, drink, clothing, and houses? For those necessaries of life many Indians of the Amazon valley are indebted to the Ita palm.

The soft inner bark of its stems is turned into a kind of flour that, in taste and appearance, closely resembles sago. The sap of the tree makes a pleasant drink. The outer bark, which is fibrous, can be separated into coarse threads. These can be woven into garments and hammocks, or twisted into ropes.

In times of very high water, the natives make floorings by stretching bark ropes from tree to tree, and covering these rope floors with boughs. An Indian family will live, for two or three months, quite comfortably in one of those airy, roofless homes.

A plant of varied usefulness is the American aloe. It grows in New Mexico and Arizona, and throughout all the tropical part of the Western Continent. This aloe plant yields fibers, from which the Guarani Indians make ropes strong enough to sustain bridges.

Two aloe-bark cables, each four inches in diameter, have held safely, since 1824, a bridge across a deep chasm in the Sierra Madre Mountains in southern Mexico.

Paper and clothing are made also from the bark, and the stem is manufactured into razor-strops. By evaporating the water from the sap, a good soap is obtained. It will form a lather with salt water as well as with fresh — an advantage not possessed by any of the common kinds of soap sold in our grocery stores.

The root of this aloe plant (more correctly termed the *agave*) is, like the potato, composed mainly of starch. The Mexicans bake the root in a mild heat for several days, thus changing the starch into a delicious, sugary substance. One variety of the agave, cultivated in Yucatan, furnishes the well-known Sisal hemp.

A species of mulberry, called the paper-tree, flourishes in the South Pacific isles. Its inner bark is so delicate that cloth made from it has the smoothness of plush.

The natives use this bark for making their "best suits." It is used also by the Chinese and Japanese in the manufacture of a very fine grade of paper.

For many years people believed the absurd fiction about the deadly upas-tree of Java—that the tree poisoned the air around it, and that any human being who should rest for even a minute beneath its branches would be thrown into a stupor that would end in death.

The story arose, probably, from the fact that the tree exudes a poisonous juice. The natives of the island dip the points of their war-arrows in this poison, and thus render fatal even a slight wound from one of them.

The need of forest products for both building and manufacturing purposes is so great that those times when the king owned the woods must have been evil times for the people.

When the power of the English monarchs was at its highest, they had the right of turning any man's farm into a forest, in which they might enjoy the pleasure of hunting beasts of the chase.

If a man owned a piece of woodland, he was forbidden by law to build a house on such ground, because the king might want to go hunting in the woods, and the people in the house might frighten away the deer and other wild animals!

The kings decreed also that every large forest should have laws of its own, and officers to seize offenders, and to throw them into prison if the forest judges ordered such punishment.

But about the middle of the 17th century, the Puritans gained possession of the government of England. Their High Court of Justice sentenced to death the weak and vicious Charles I., then monarch of England; and their Parliament abolished the hard and unjust forest privileges, which, up to the year 1641, belonged to the English Crown.

Let us be thankful that our own great country still contains many square miles of woods. Let every pupil in this school try, on next Arbor Day, to plant a tree or a flower-bush; and let us all endeavor to preserve those trees that now beautify our streets and roads. Finally, let us bear in mind that not only are forests useful and beautiful, but that also they were the churches and schoolhouses of ancient days.

> "The groves were God's first temples. Ere man learned
> To hew the shaft and lay the architrave,
> And spread the roof above them, — ere he framed
> The lofty vault to gather and roll back
> The sound of anthems, — in the darkling wood,
> Amidst the cool and silence he knelt down,
> And offered to the Mightiest solemn thanks
> And supplication."

Lesson XXIII.

The First Metal Used.

Away up in the northern peninsula of Michigan, near the south shore of the largest body of fresh water on the globe, —

> "the mighty lake
> Whose long and solemn-sounding waves
> Against the sunset break,"

is the world's best-known copper mine.

For centuries the Chippeway Indians had roamed over Lake Superior's southern coast and the adjoining territory, and had never even attempted to avail themselves of the wonderfully rich deposits of copper beneath their feet.

The red men did, indeed, now and then, pick up lumps of the dark-brown metal, because the fur-traders from distant Quebec were willing to exchange glass beads or scarlet cloth for them. The copper ore, however, was left untouched. The Indians were not civilized enough to know how to work it.

Their traditions gave no hint of the Mound Builders, the earlier inhabitants of the country, and therefore the Chippeways believed themselves to be the first settlers. The white people were of

the same opinion. Hence, when United States surveyors found, by accident, the remains of very ancient mining-works, the discovery created no small astonishment.

These relics of an unknown people are met with on the hill-crests of Isle Royale and also near the present town of Ontonagon. Trees, many hundred years old, now grow in pits dug with great labor by the Mound Builders. Those early miners managed to cut through solid rock with tools of stone or of copper that had been hardened by some process which is now one of the lost arts.

Shafts sunk thirty feet deep in the hardest greenstone have been discovered. They were, of course, filled with leaf-mold and earthy materials, which century after century had slowly heaped up. In several pits the first explorers came across the old tools used by the mysterious, long-dead miners. Stone hammers, stone picks, and copper chisels seem to have been the implements most commonly employed for cutting into the hard vein-rock.

In one mine a mass of copper weighing several tons was found resting on wooden rollers — a circumstance that proves that the Mound Builders had considerable knowledge of machinery.

Copper blocks were discovered, which had large cubes chiseled out of them. The mode in which

the mines were worked and the means employed to conduct the mining operations give proofs of a skill and an industry quite foreign to the nature of the wild and idle race of hunters whom the white men found in possession of the peninsula.

A company of explorers, led by General Cass, brought back, in 1819, glowing reports of the richness of the copper deposits of the Lake Superior region. These did not attract public attention, however, till about thirty years afterwards. Then, a sort of mania for copper-mining seized on many people, and thousands of shafts were sunk along the shore of the great lake.

But as no copper was obtained from the most of the pits, numerous companies failed, and the people who had intrusted them with money were compelled to suffer its loss. A few mines, however, were very successful; and these, in later years, retrieved the reputation of northern Michigan as the region of the most valuable copper deposits on the globe.

The richest mine was discovered in a singular manner. A party of explorers were looking for copper ore in the territory around the site of the present prosperous town of Calumet. The keeper of their boarding-house lost several of his hogs, and, after a long search, found them in an old pit, about a mile from the house. The opening of the

pit was almost hidden by bushes, and the trees growing about the sides of the excavation gave evidence that centuries must have passed since it had been dug.

Some stone hammers and charred sticks suggested that the pit had been made by the Mound Builders. But this strange people looked for copper in lumps only, it seems, and probably could not separate the metal from the ore, which occurs in veins running through rock.

The hogs had turned over pieces of rock formed by the action of water — aqueous rock — and those pieces contained copper. This discovery seemed to be a valuable one; but when it was published, experienced miners refused to believe that copper would be found in paying quantities in such rock.

All the vein copper hitherto mined had come from fire-formed rocks, they said, and the extraordinary copper-bearing aqueous rock found in the pit discovered by the hogs was simply a freak of nature. So declared those men, who thought themselves wise in mining matters. A man of science, wiser than any of them, the great naturalist, Agassiz, advised a friend to buy the pit and several hundred acres of the land round about it, and to begin to mine for copper.

The richest known deposit of that metal was soon struck — a deposit that still yields millions

of pounds of copper annually, after having been worked constantly for over a score of years past.

The copper-mining industry has built up, in that northern wilderness, several busy villages, having all the benefits of civilized society.

But an enormous amount of money has been spent in developing the mines. The machinery for one shaft cost $1,500,000. The granite on which it rests was brought from Massachusetts. The castings were made in Philadelphia.

The hoisting engine is one of the most powerful ever constructed. It lifts trucks full of ore from the bottom of the pit — 4,200 feet below — and dumps their contents into freight-cars.

These are hauled to the immense mills on Lake Linden, which is not far distant. There, the ore is ground to powder, and the rock particles are washed away, the copper being left, in a flour-like state of fineness, on the washing-tables.

The pumping-engines draw up daily, out of the largest mine, millions of gallons of water, which is allowed to flow off into a lake near by. Six days in the week and twenty-four hours in the day the work of copper-mining is carried on in this mine.

In no other locality have such huge masses of copper been found. In 1869 there was discovered a block sixty-five feet long, thirty-two broad, and four feet thick. This king of copper nuggets

weighed over 1,000 tons, and was worth about $400,000, or more than the largest lump of gold that has yet come to light.

But Montana may now boast of the greatest copper mine in the world. Its hoisting machinery lifts daily 1,500 tons of ore; and this prodigious amount of metallic rock is crushed, and the copper separated from it every twenty-four hours. Over 2,000 workmen are employed. The thriving city of Butte owes its origin to this exceedingly valuable mine.

Arizona produces a large amount of copper. Rich deposits of the metal are known to exist in Utah, Colorado, Nevada, California, and other States. Copper and mercury are the only metals that we export in large quantities.

Mining for copper is carried on in twenty-one States and two Territories.

This country's output of copper is so large that it governs the price of the metal in the markets of the world. Chili ranks next to the United States in the production of copper. The metal is extensively mined also in Australia, Spain, and Japan.

Next to iron, copper is the most useful of the metals. In a pure state it is of a fine red color, is very malleable and tenacious, and is a good conductor of electricity.

The increasing use of electric force has called

for large supplies of copper, and has thereby greatly stimulated the production of the metal. One Pittsburgh firm that constructs electric machinery used, in 1891, nearly 4,000,000 pounds of copper.

We must remember that this metal is employed also for making various household utensils, for coins, and for producing colors (green and blue). It enters into the composition of brass, bronze, bell-metal, and German silver.

As the art of iron-working extended in Europe, during the Middle Ages, copper-working fell into disuse, except for the making of objects of art, such as chandeliers for churches.

But with the dawn of the Modern Period, about the date of the discovery of America by Columbus, the value of copper in the industrial arts began to be recognized. In the 16th century Augsburg and Nuremberg, Germany, became centers of copper-working industries.

Copper vessels of every size, from sauce-pans to huge boilers, were fashioned in "Pansmiths' Row," in Nuremberg — a city that was, till recent times, the home of German handicrafts. Its master copper-smiths bought copper in Flanders, and sent the products of their shops to nearly all parts of the commercial world.

One of those masters grew so rich that his neighbors accused him of being a sorcerer. They

said that he knew how to change copper into gold. It was true that he could, in one way, effect this wonderful change: he could effect it by hand and hammer, — by the smith's art, and not by the Black Art.

So greatly prized were the copper manufactures that the robber knights of that time thought themselves quite fortunate if they chanced to capture any such wares. The copper came from the mine of Fahlun, Sweden, the oldest one in Europe, and from mines in Hungary, Bohemia, and Saxony.

The art of tinning copper utensils — an art lost since the times of the Romans — has been recovered in the Modern Period. More beautiful results are produced by the processes of gilding, silvering, and enameling. These modes of covering copper not only give it a more agreeable appearance, but they also guard against the poisonous effects of vinegar and other acids on the metal.

The compounds of copper have in modern times become of great importance. Bronze is used very extensively in making such small articles as statuettes, inkstands, vases, lamps, clocks, gas-fixtures, and paper-weights.

Most of these articles are produced in Paris. Bronze-work in that city employs thousands of hands, and the value of the yearly product is more than $8,000,000.

Brass, an alloy of copper and zinc, is so generally used that no other metal, except iron, is applied to so many purposes. Like copper, brass spreads out under the hammer into thin sheets. The manufacture of sheet brass, by beating it out with hammers, was formerly a profitable industry, but it is now superseded by rolling — that is, by drawing a bar of brass between heavy iron rollers.

The annual product of the brass-founderies of the United States is estimated to be worth the large sum of $55,000,000. Yet this highly important industry of brass-casting had its origin in a Connecticut mechanic's attempt to make a few buttons!

When British war-ships stopped the commerce of the ports on Long Island Sound in 1812, many articles of foreign manufacture became scarce, buttons included. A wood-turner named Aaron Benedict, living in Waterbury, Connecticut, believing that buttons could be made in this country as successfully as in England, began, in a humble way, the manufacture of those articles, using bone as the raw material.

His business prospered until fashion decreed that gentlemen should have only gilt or brass buttons on their coats. Benedict, finding that trade was slipping away from him, determined to make fashionable buttons.

The change from bone to metal was effected in 1829—a change by no means easy to carry out then. The sheet-brass, from which the buttons were cut, had to be imported from England in sailing-vessels, and to be hauled in wagons from New Haven to Waterbury.

The English firms that supplied the brass would not roll it thin enough to suit Benedict or his partner, Coe. The Yankees decided to roll the metal for themselves. Men less self-reliant, or less ingenious, would have been daunted by the lack of machinery and also of copper, the main ingredient in brass. The young Waterbury mechanics had no money to import the necessary metal and machines.

But where there's a will there's a way; and those two energetic workers traveled on foot through western Connecticut, purchasing worn-out copper kettles and pans. These, laboriously cut up by hammer and chisel, were melted, with the requisite zinc, in an iron furnace; for the young firm could not afford to buy a crucible.

The molten metal was poured into a rude mold, and the slabs of brass cast in that rough manner were hauled to an old, iron rolling-mill, several miles away. There, they were passed between the rolls until the brass was reduced to the required thinness, the needed tempering after each rolling

being done in an open fire of wood, burning in the mill-yard.

It seems strange that buttons fit to be worn could have been made by the crude methods employed in the first year of Benedict and Coe's brass-founding. But skill and perseverance conquer all difficulties, and the humble Waterbury firm became, in after years, the owners of the largest brass-works in the world.

The first company that grew wealthy by mining Michigan copper was formed by Coe. It was he also that first wrested away from English metal-workers the secret of making brass malleable enough to be beaten into kettles. Congress gave him a gold medal in honor of the great services he had rendered the metal industries of the United States.

His life is an inspiring example to every boy that may be compelled by poverty to struggle for years against trials and misfortune. When surrounded with difficulties, let us remember that if we have the will to force our way through them, we shall certainly find the way. Every one is the builder of his own fortune. Self-help is the best help.

"Let us then be up and doing,
With a heart for any fate,
Still achieving, still pursuing,
Learn to labor and to wait."

Lesson XXIV.

From East and West.

Tin is one of the metals most anciently known to man. Its first discovery is hidden in the darkness of remote antiquity, and even the names of the nations that first worked this beautiful white substance remain to be found out.

Axes, lances, sickles, and fish-hooks of bronze — the familiar alloy of copper and tin — occur among the ruins of houses erected on posts that were set in the beds of Swiss lakes. Those houses, or huts, had disappeared centuries before the Romans conquered Switzerland. From this fact, and from other historical evidence, we infer that the weapons unearthed from the mud of the lakes must be at least 4,000 years old.

As these tools of warfare contain tin, that metal must have been known for ages before it made its way from the far-off East to the savages inhabiting the most mountainous part of Europe.

We have already learned that the Phœnicians obtained tin from the south-western part of England. Governed by the jealous spirit of trade, they kept secret for many years the location of the tin mines; but about 450 B.C. the Greeks as-

certained that there was situated in the Atlantic ocean, north-west of France, a great island which produced tin.

Four centuries later, a writer on geography, Diodorus Siculus, who tells us that he visited England, gives an interesting sketch of that country's tin trade. Here is, in part, his account, translated from the Greek, the language in which he wrote: —

"The inhabitants of that end of Britain which is called Bolerion [Cornwall] are, by reason of their intercourse with foreign merchants, quite civilized in their mode of living. The ground of their territory is rocky, but has in it earthy veins, from which they extract tin. This they cast into cubes, and carry to a certain small island, called Iktis, adjoining Britain.

" At full tide the way to this island is overflowed, but when the sea retreats a large tract is left dry, and this land the tin merchants make use of as a passage-way. The traders purchase the tin of the natives, and transport it across Gaul [France] on horseback. It requires about thirty days for them to bring their burdens to the river Rhone."

From this brief sketch we learn how the tin of Britain was brought, in the time of Julius Cæsar, into Italy, then the great commercial country of the world.

But long prior to that period the tribes occupying Cornwall must have discovered the value of the white metal treasures of their rocky territory. Lumps of tin that had been smelted in rude clay furnaces were very early employed as articles of barter by the Cornwall people, in trading with the other tribes of Britain and with their kinsfolk that inhabited the north-western part of France.

When we consider the various and important uses to which tin may be applied, we cannot wonder at its extreme value in the commerce of the ancient world.

We learned in Lesson XVI. that the discovery of the secret of making bronze marks one of the great epochs in the progess of mankind. The tribe able to supply its warriors with bronze weapons became at once superior to the tribes having only stone hammers, stone axes, and flint spearheads for arms.

At a later period, when iron had for most purposes superseded bronze, the many useful qualities of tin caused it to be still highly esteemed. Possessing a luster not inferior to that of silver, tin, like silver, may be kept bright for a long time.

Under the hammer, tin is extended into leaves, each only a thousandth of an inch thick. These form the tin-foil of commerce. Tin is the chief

ingredient in pewter, in type-metal, in britannia metal, and in other alloys that are manufactured into articles of table-ware.

Tin is the substance which, coated with mercury, is employed to make the reflecting surface of your mirror. In dyeing processes tin, dissolved in acids, furnishes very valuable mordants — the mediums by which vegetal dyes are rendered fast. The beautiful crimson-stained glass which you have admired in church windows was colored by a compound of tin and gold.

Most of the world's present supply of tin comes from lodes, or veins, running through rock. The metal is found also, like gold, in dried-up river-beds. This stream-tin, as it is termed, occurs usually in grains.

It is obtained by washing the earth. This was the oldest method of tin-getting; but, like the gold placers, the tin placers have been worked out. Now the white metal must be sought hundreds of feet deep down in the earth, and the miner must drill through hard rock.

Perhaps the most remarkable tin-mine ever worked was opened off the Cornwall coast, in the latter half of the 18th century.

About two miles south-east of the town of Penzance there was, the miners knew, a knobbed expanse of rock that was crossed in every direction

by numerous veins of tin ore. At high tide this rocky spot was covered by the sea.

In the year 1778 Thomas Curtis, a poor miner, was bold enough to attempt to work those tin deposits. They were under twenty feet of water about ten months in the year; while, during the winter and the spring, the surf rolled over the rock so violently as to render useless all efforts to carry on mining operations.

Yet a poor, uneducated man determined to overcome all those difficulties. As he could labor at his task only while the tin-bearing rocks were above water, he had to spend three summers in sinking a pumping shaft.

A turret of planks, made water-tight by oakum and pitch, and carried up to a sufficient height above the spring tide, was then placed over the mouth of the shaft. A board platform, on which four men could stand, was fastened on the top of this singular structure.

As the platform was two feet above the highest tide, the miners expected to be able to work the tin veins throughout the year. But their hopes were disappointed; for, when the first side shaft had been cut through only a few feet, the sea water leaked into the mine, and pumping had to be carried on day and night.

To add to the hardships of the situation, the surf

was so heavy during the winter-time that the transporting of the tin-stone to the shore of the mainland became almost impossible. Nevertheless, the deposits were so valuable near the surface of the

Tin-Workers.

sea-floor that the owner reaped a rich reward for his courage and perseverance. He drew many thousand pounds of tin out of this strangely located mine.

It was closed by a singular accident. One night during a terrible storm, a ship from Philadelphia

broke from her anchorage in Penzance harbor, and, drifting out to sea, struck against the turret, and tore it from its underground fastenings.

The shafts and galleries that it had taken years to quarry out were flooded in an instant. Thus came to an end a mining enterprise that, in ingenuity, daring and success, has probably never been equaled.

Tin is seldom found pure. Sometimes it occurs in zinc ore combined with sulphur. As the manufacturing world uses thousands of tons of tin yearly, a mine of this metal must be a valuable possession.

We may, therefore, be interested in the answer to the question: What countries yield tin? The Malay Peninsula, in Farther India, two islands in Malaysia, Banca and Billiton, the province of Queensland, in Australia, England, and the United States. Deposits of the metal are worked in California, Colorado, and South Dakota. The dressing of tin-ore — that is, the process of removing the earthy matters mixed with it — begins with cleaning, and goes on to washing, to crushing, to smelting in the furnace, and, lastly, to refining.

The world's yearly output of tin does not exceed 45,000 tons. Most of it is used for making tinplate. Squares or strips of sheet-iron are put in vats of molten tin. The iron soon becomes cov-

ered with a tin coating which adheres very firmly. Tin-plate is employed for making household utensils, roofing-plates, cans for our various canning industries, and numerous other articles. The United States uses more of this tinned sheet-iron than any other country.

Lesson XXV.

Lead and Graphite.

When cities began to plan systems of water-works, the question arose, "What metal shall be used for making the pipes in which the water is to be conveyed through buildings?" Civil engineers agreed that the metal must be flexible enough to be bent easily, and yet must also be durable and not liable to rust.

The introduction of lead pipes was strongly opposed by many persons. It was said that water flowing through such pipes would soon become poisonous. Men of science denied that this evil effect would follow. Time has proved that the scientists were right. The lime in the water soon coats the inside of the pipes, thus rendering them quite harmless.

But it is only lately that we have learned that

water was carried through lead pipes into houses in Rome 2,000 years ago. Lead was, however, a metal little prized by the ancients, though evidently it was well known to them.

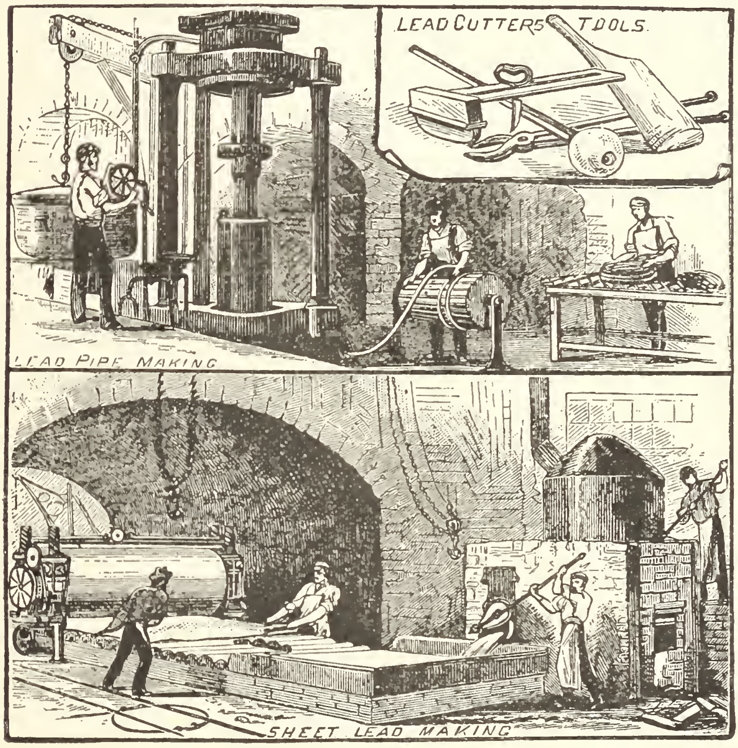
"Oh, that my words were graven with an iron pen on tablets of lead!" exclaims the long-suffering patriarch, Job. The great legislator of the Jews, Moses, commands his people to "make go through the fire . . . lead and everything that may abide it." We infer, however, from certain other passages in the Old Testament, that the Hebrew people made but slight use of lead.

Long prior to the Exodus from Egypt, the Phœnicians used the metal to increase the weight of their anchors. The "Father of History," Herodotus, describing a Babylon bridge, says that the pier stones were held together by iron clamps soldered with lead.

How many industrial uses of this metal can you mention? The making of bullets and shot? Yes: those articles have mercantile value. But you do not, of course, mean the old, round bullets which were cast in a mold. They have disappeared forever from the market. This modern world of ours moves too fast to be contented with slow work in any industry, no matter how well that work may be done.

To-day bullets are cone-like in form, and are

produced by machinery. A rope of lead is wound on a large reel, from which it is fed to a machine. This cuts off very rapidly pieces of the lead, and forces them into dies, which shape them into small



Lead-Working.

cones. These are then ready to be made into cartridges.

The leaden rope, or rod, is fashioned in a very ingenious and yet very simple manner. Molten lead is poured into a massive iron pipe. When

the metal has cooled into a half-solid state, a *plunger*, a long, steel bar, closely fitting the bore of the pipe, is pressed down on the lead.

A round opening runs through the entire length of the plunger; and as this bar is pushed down with enormous force on the pasty lead, the metal is crowded through the opening, coming out at the top in the form of a cord or flexible rod, quite solid, though still hot. The cord is wound on large iron reels as fast as it emerges from the plunger. Shot is formed by pouring molten lead through sieves, and allowing the particles thus produced to fall into an immense tank of water about two hundred feet below.

The leaden pipes which are so commonly used for conveying water and gas through our houses are made in a very ingenious manner. A solid iron rod, having its diameter the required bore of the pipe, is placed in the opening of a plunger of wider bore. The lead in escaping between the rod and the sides of the opening takes the form of a pipe.

The types from which ordinary printing is done are made of a metal composed of lead and antimony. In the manufacture of glass and crystal, lead plays an important part, being one of the chief ingredients of flint-glass and crown-glass. Lenses made of these kinds of glass have wonder-

fully improved the distinctness and power of our telescopes and marine-glasses.

Lead in sheets is employed for roofing; and, when the sheets are rolled to the thinness of tin-foil, they are used for lining tea-chests, and for covering many small commodities, as yeast-cakes and certain articles of confectionery.

Two oxides of lead are of great importance in the industrial arts — litharge and minium.

When lead is melted in a furnace through which a strong current of air blows, litharge is produced. It is used in cements, in oil-varnishes, in preparing lead plaster, in glazing earthenware, and as the basis of certain color materials.

Minium, or red lead, is also a paint.

Molten lead acted on by carbonic acid becomes the well-known pigment, or paint material, called white lead. This is manufactured on a vast scale. Sugar of lead is of great value to the chemist.

It is well to remember that all these preparations of lead are extremely poisonous.

Native lead occurs only very sparingly. The most plentiful and important of lead-ores is *galena.* This ore contains sulphur, lead, and silver, and is found very abundantly in the limestone rocks formed during that same period in the history of the earth's crust in which coal was made — the Carboniferous Era.

Pounding, washing, and smelting prepare the metal for the manufacturer.

In ancient times lead-ores were smelted in very rude forges. These were placed on the summits of high hills in order to get the benefit of strong drafts of wind. Smelting is now conducted in blast furnaces.

As lead melts at a low heat, the loss of metal by furnace smelting would be considerable, on account of the fierce fires employed, if no preventive measures were taken. The furnace fumes are condensed by being passed through water, or else water is sprayed into iron chambers through which the lead vapors are made to circulate.

In the latter part of the 17th century it was thought remarkable that the Dutch, in working their lead-mines in Malaysia, should find it profitable to separate the silver from the lead when one ton of the latter metal contained only three pounds of the former. Now, by improved processes, the silver may be profitably removed if there are three ounces of it in a ton of the lead.

This gain in smelting is due to the thoughtfulness of a young workman named Pattinson. He noticed that in a molten mass of lead and silver the lead, on cooling, formed into solid crystals while the silver was still fluid. This discovery is the basis of modern lead-smelting.

By repeatedly melting the lead, and removing the crystals, the liquid portion of molten metal remaining becomes very rich in silver. This fluid metal is then put into a kind of crucible, and

Smelting Lead.

is exposed, in a refining-furnace, to a strong blast of hot air, fresh supplies of lead being introduced from time to time.

By this means the lead is oxidized and converted into molten litharge, which is poured off into a

receiving-vat. The silver is found hardened into a cake at the bottom of the crucible.

When the last particles of lead have separated from the silver, the latter metal shines forth lustrously; and this sudden brightening of the silver marks the moment at which the hot blast should be turned off, and the fire be put out.

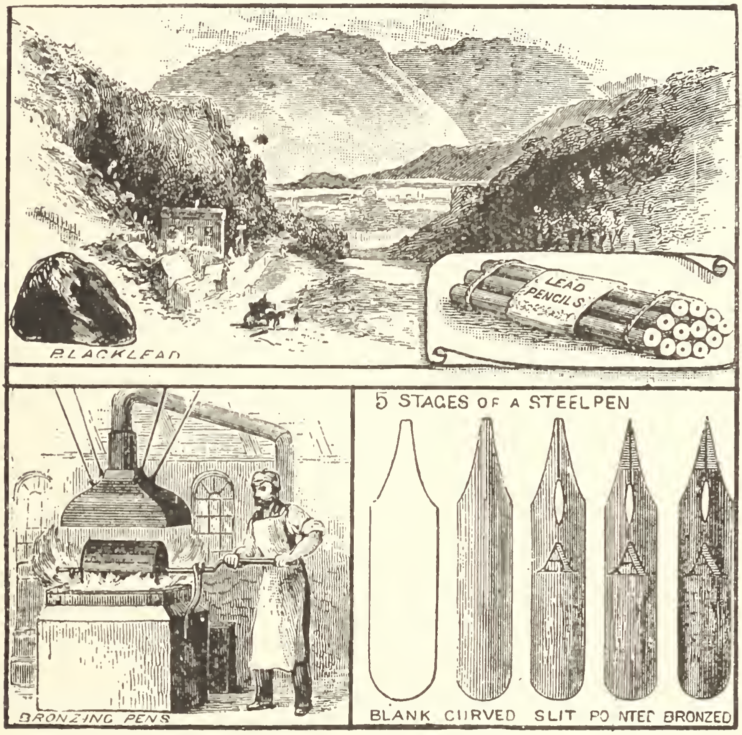
Ores so poor in the precious white metal that, formerly, it would not pay to desilverize them can now be profitably treated by the modern method. This is another example of an important practical result following, unforeseen, an advance in an industrial art. Pattinson's discovery also shows the value of bestowing thought and care on our daily tasks, does it not?

Immense deposits of galena are found in Illinois and Wisconsin, but they are not worked extensively. Lead is mined also in Iowa and Missouri. Colorado's silver ores contain lead, and the enormous quantity of these ores smelted yearly in the Centennial State enables her to outrank every one of her sister States in the production of both silver and lead.

Until 1890 Spain was the chief lead-yielding country. Now half of the world's annual product of lead, 380,000 tons, is mined in the United States. Germany and Great Britain also yield considerable quantities of this metal — a metal

that has become of increased importance since the beginning of this century.

Is it not strange that we persist in calling a certain little writing tool a lead-pencil, although



Borrowdale. Pen-Making.

it does not contain a particle of lead? A pencil's "lead" is really *graphite*, a mineral consisting chiefly of carbon.

It occurs generally in lumps or masses in rocks that split into planes. These vein-like deposits of graphite (which is also called blacklead and plum-

bago) are met with in Canada and the United States. But the largest share of the world's supply of this mineral comes from Siberian mines.

The graphite from Ceylon is highly esteemed by lead-pencil makers.

The rough slabs of the mineral are planed smooth, and then are cut into strips by long, thin blades set together like the blades of a gang-saw. These strips are cut crosswise into pencil lengths, which look like tiny iron bars.

A length placed in a groove channeled in a strip of wood by machinery, another strip of equal size glued on the first one, and the wooden case forced through a rounding apparatus, comprise the main steps taken in making a pencil.

Inferior grades of graphite are used for stove-polish and crucibles.

A graphite mine, discovered in the last century near Borrowdale, England, proved to be of exceeding richness. For a long time this mine was the world's best-known source of the mineral, and netted its owners £100,000 annually. It had to be guarded by armed men as closely as if the lumps of carbon were nuggets of pure gold.

At one time even the guard did not suffice to protect the black treasure; for a band of resolute thieves overpowered the watchers, and for some days held possession of the mine.

After its owners regained it, they erected a stone building over the entrance to the mine, and thus were enabled to keep their precious graphite from being carried off by future robbers or thieves. This once famous mine is now exhausted, and is, therefore, no longer regarded as worth protecting.

Lesson XXVI.

The Heaviest Fluid.

A government surveyor visiting a little church, built in western California by a tribe of Christian Indians, noticed that the walls were colored a most beautiful red. On inquiry he learned that the paint material, or pigment, was a kind of red earth. A handful was given to him, and he recognized it as that exceedingly valuable mineral, *cinnabar*, the most common ore of mercury, or quicksilver as this metal is often termed.

He induced an Indian to lead him to the mountain from which the ore had been taken, and the richest quicksilver deposits ever known were soon revealed to civilization. A flourishing town, New Almaden, quickly sprang up near by. To-day

mercury is one of the most important items in California's list of metallic treasures.

As this substance remains always fluid in temperate climates, the ancients did not consider it a true metal. They never subjected it to a temperature of 40° below zero; hence they were unaware that the metal becomes solid and malleable at that degree of cold.

"Water-silver" was the meaning of the name given by the Greeks to mercury. The Romans designated it by two Latin words, meaning "live silver," a phrase from which our term *quick*silver comes. In the Middle Ages the name of a planet, Mercury, was bestowed on it by the alchemists.

These men believed it possible to transmute into gold all the baser metals. Mercury was made the subject of numberless experiments. Though these failed to bring about the desired change, yet they led by accident to the discovery of several compounds of this strange fluid — compounds that have ever since been classed among the most valuable medicines.

It has, however, been reserved for modern scientists to reveal the full importance of mercury, and to extend widely its field of usefulness.

Alloyed with tin-foil, mercury probably forms the reflecting surface of every looking-glass in your house. Large quantities of this fluid metal

are used in the United States to extract gold and silver from their ores.

To science, quicksilver is a highly valuable substance. It is preferred to all other liquids for filling the tubes of barometers and thermometers, because it is very dense, and it expands and contracts regularly, according to the changes of temperature to which it is exposed.

It has been of great service to the chemist; and without its aid many a branch of industry, now adding to the nation's wealth, could not be carried on successfully.

In a mountain near Almaden, Spain, there is a very old and valuable quicksilver mine. Though centuries have passed since it was opened, the deepest shaft has been sunk only 1,400 feet.

The ore presents a beautiful sight in the mine galleries. The visitor sees his candle-light reflected from the cinnabar in countless rays of glittering crimson.

Often when a hewer loosens with his pickax a block of the mineral, a quicksilver mass, perhaps the size of an egg, rolls down from the crevice in which it has lain hidden for millions of years, and, leaping along the floor, divides into thousands of drops. These, however, are carefully collected by men provided with suitable tools and with vessels for carrying mercury.

Formerly, only criminals condemned to hard labor for life were employed in the Almaden mine. At sunrise they were conducted through a tunnel leading from their prison to their place of daily toil. They were compelled to work till night, when they were led back to their dungeons, so that the wretched prisoners never saw the light of day.

The mercury was at that time extracted from the cinnabar by roasting the ore in open furnaces. This process filled the air with poisonous vapors, and the unfortunate men who tended the furnaces died in great numbers. Reduced to despair, the convicts set fire, about two centuries ago, to the wooden supports and boarding of the galleries; and, the roofs falling down, no mining could be done for some years.

Since then, only free miners have been employed. They are well paid, and are not required to work more than six hours a day. Most of them, however, die at an early age. The few that reach forty years are afflicted with an incurable palsy, and are unable to keep hand or arm at rest.

In one of the largest and most picturesque basins of the Julian Alps lies the neat little Austrian town of Idria. The gigantic mountains which inclose the quiet valley are covered on their summits with snow; but, lower down the slopes,

the eye is gladdened with the sight of clumps of oak and of beautiful meadows and sunny glades. Here and there, on rocky spurs, stand quaint, ivy-decked buildings, which serve to heighten the beauty of the landscape.

Chance led to the finding of rich underground treasure in this lovely vale. In the year 1497 a peasant discovered, in a tub that he had placed under a spring flowing out of the mountain nearest to Idria, some drops of a very heavy liquid shining like silver.

He carried them to a goldsmith, but was cunning enough to keep to himself the secret of the locality where he had found them. At length a company of wealthy Germans paid him a large sum for pointing out the source of the mercury deposits.

The mine was then opened, and for several years it yielded profits so large that, in 1510, a body of Venetian robbers, spurred on by greed, invaded the valley, and drove away the German owners. The robbers did not, however, keep possession of the mine very long. As soon as the Emperor Maximilian heard of this insolent invasion of his territory, he sent troops to Idria, and they quickly put the foreign thieves to flight.

For three centuries, hundreds of wooden beams had been every year brought into the mine for

gallery props. One day, in 1803, some workmen saw a thick volume of smoke rush up out of one of the shafts. The mine was on fire! Poisonous vapors rapidly filled the galleries, suffocating a few of the miners, and compelling the rest to flee for their lives.

An attempt was made to smother the fire by shutting out the air. The mine remained closed for five weeks. When it was reopened, the flames burst forth more furiously than before.

The fire now roared fearfully from the depths of every pit, and the fumes of mercury and sulphur threatened instant death to any person rash enough to approach the entrance. The superintendent resolved therefore to flood the works as a last resort.

A stream flowing through the valley was turned into the mine, and ran into it for a day and a night. On the second day a terrific explosion took place. The whole mountain trembled, as if shaken by an earthquake, the stone houses on the slopes fell in ruins, and the inhabitants of Idria fled in terror to the hills.

Within the mine, the walls dividing galleries and shafts were torn away, the roofs were burst through, and the sides were thrown down. But the victory over the fire was complete, and in a few weeks some miners ventured into the pit.

Two full years, however, passed away before work could be resumed.

The water from the mine, pumped out into the river Idriza, poisoned all the fishes therein, except the eels. The eel seems able to live in any kind of water — unless it be boiling hot.

The new galleries are walled with stone, and their collective length is fifty miles. The cost of the walls is less than one would suppose, as the progress of the mining operations furnishes most of the necessary material.

The task of the quicksilver miner is both disagreeable and dangerous. His work is done in dismal excavations by the weak glimmering of a candle, and in an atmosphere full of deadly vapors. An early old age is his lot, and death generally overtakes him before he reaches his fortieth year of life.

From cinnabar, the best-known ore of mercury, is made the beautiful pigment, vermilion. But the ore itself was much used in ancient times for painting the faces of warriors and of guests at the feast table.

The extent to which cinnabar was employed as a face-paint may be inferred from the statements of Pliny, a famous Latin historian, that the Greeks imported cinnabar from Almaden long before the reign of Alexander the Great, and that Rome, in

his own time, received 700,000 pounds of the mineral from the same mine.

Metallic mercury is obtained from the ore by roasting it with lime in furnaces. How is the metal transported from the reducing furnaces to the places where it is used?

Until about thirty years ago the mercury was, at Idria and Almaden, poured into sheepskin sacks, each containing about forty pounds.

If a sack, thus filled, stood the test of being pressed and rolled about on tables, it was inclosed in a second sack of rawhide, and was then placed in a cask, and this cask was fastened up in a square box. But despite the care taken, the mercury often broke through its four inclosures, and was lost.

At length an Austrian engineer conceived the idea of using large iron bottles with stoppers (also of iron) that could be firmly screwed down by means of machinery. All the quicksilver reduced in Europe and the United States is now sent in such bottles through the channels of commerce. Each bottle holds seventy-five pounds of the metal, and loss by breakage is unknown.

These safe and convenient iron vessels must be far superior to the old, unwieldy skin-sacks, casks, and boxes, must they not? Sometime we all shall have opportunities to improve some of the

world's methods of working; therefore let us now, while at school, study diligently, in order that we may be fitted to do our own special life-tasks well and to help our less fortunate fellow-creatures.

Lesson XXVII.

New and Valuable.

It is only within the last fifty years that Zinc has been recognized as one of the most important products of the mineral kingdom. Yet the metal was smelted ages ago in India and China. The Portuguese brought zinc ornaments from Hindustan to Europe in the 16th century.

Calamine and blende, the most plentiful ores of the metal, were familiar minerals to the Romans. By reducing them with copper ore, they obtained an alloy similar to our brass. But pure zinc seems to have been first discovered by the famous alchemist, Paracelsus, who flourished in Switzerland about 300 years ago.

The metal's varied usefulness was, however, not suspected until the year 1805, when two chemists having, by accident, heated zinc white-hot, found that it could be then easily worked. At ordinary temperatures zinc is brittle. But careful experi-

ments have proved that, when this metal is exposed to a heat higher than 212° F., it may be drawn out into wire, or be beaten into thin plates.

As soon as it was ascertained that zinc could be readily rendered malleable, its hardness and cheapness caused it to be preferred to lead for many purposes for which manufacturers had previously used the latter metal.

Rolled into thin sheets, zinc becomes a valuable material for making pails, pans, and other household articles. The metal, being light and durable, is frequently employed for roofing buildings. Many architectural ornaments are molded of zinc, and bay-windows made of zincked sheet-iron may be seen by the thousand in every large city.

Suppose zinc should be heated more than is necessary to render it malleable, what would be the result? The metal would become brittle, and, when cooled, could be easily powdered. At 806° F., it fuses, and can, of course, be readily poured from one vessel into another.

What change will take place if the zinc be heated still higher? It will vaporize. If the vapor be set on fire, it will burn very brilliantly, and be converted into oxide of zinc. This chemical is used in medicine, is a familiar ingredient in pottery colors, and, as a white pigment, is a strong rival of white lead.

The various applications of zinc have created so great a demand for it that its production has, in the last half-century, made strides unequaled in the history of metals. Before 1805 about 200 tons represented the annual amount of zinc utilized by America and Europe. 300,000 tons were consumed by those grand divisions in 1891.

Germany produces more of this metal than any other country, the United States and Belgium ranking next in order. Our zinc-yielding States are Missouri, Kansas, Pennsylvania, New Jersey, Tennessee, and Nevada.

The metal is never found pure. Zinc, sulphur, and iron form the ore called blende. Calamine is composed mainly of carbon and zinc. Lead is generally found in the zinc ores mined in this country.

Crushing and roasting the ore comprise the chief steps taken to obtain the metal.

The roasted ore, mixed with ground coke, is put into fireclay vessels, and these are placed in a furnace like a glass furnace. From an opening in the bottom of each vessel an iron tube runs down about eight feet to an iron vat.

A charcoal plug prevents the coke and ore from going down the tube, but allows the zinc vapors to pass through, the charcoal being quite porous. After the volatilized zinc has condensed in the

vat, it is melted, and cast into ingots small enough to be handled with convenience.

Zinc finds its most extensive use in coating iron. Galvanized iron is the term by which this zinc-plated metal is known. It never rusts, and is of great value in the construction of small, light buildings.

Churches and houses have been made of plates of sheet-iron coated with zinc. Such structures are often sent, in numbered sections, to missionaries in savage lands, such as western China, some Pacific islands, and Africa.

The plates can be readily fastened together with nails, these being zincked also. Galvanized iron is further utilized for constructing water-tanks and rain-spouts, and in England all telegraph wires are made of this material.

Zinc is useful in engraving, in printing, in medicine, and in manufacturing electrical apparatus. A compound of sulphur and zinc, known as "white vitriol," is an essential agent in numerous industrial processes.

We perceive now that zinc renders valuable service to mankind. The metal's manifold forms and compounds represent the labor of thousands of men. Were these workers not thus furnished with employment, they would be forced into other occupations already overcrowded and poorly paid,

or would be compelled to beg, or to ask for public charity.

The workmen in the gold mines near Choco, South America, often found mixed with the gold an unknown grayish metal. This became an object of curiosity when it proved to be able to resist the strongest heat.

A Spanish traveler named Ulloa carried to Europe, in 1735, some specimens of this strange substance. It remained of no commercial value, however, till a German chemist succeeded in bringing it to a white heat. In this state it can be drawn into wire, and is, of course, malleable, but is not brittle.

A few years afterwards a Swedish scientist, Bergmann, had his attention called to this singular mineral. He examined it closely, and decided that it was a compound of several metals. By careful experiment he proved that his opinion was correct. As a result of his labors, he presented PLATINUM to the world.

Platinum is found in almost all gold-placers, but generally in quantities too small to repay collecting. It rarely occurs pure. Gold, iron, and the exceedingly rare metals iridium and rhodium, are the common alloys of platinum.

The yield of this metal is small. Brazil, Colombia, California, and Borneo produce, all to-

gether, perhaps as much as is mined in Russia, — that is, about 10,000 pounds annually.

But in spite of this scanty production, the utilizing of platinum must be considered one of the most important conquests that science has made in the material world.

The metal withstands a heat that will fuse sand or fireclay, does not rust under any circumstances, cannot be corroded by acids, and is therefore invaluable to the chemist. Many very beneficial discoveries of modern science could not have been made without the assistance of platinum.

To the manufacturer of sulphuric acid (a liquid much used in the industrial arts) stills constructed of this metal are of the greatest utility; for that highly corrosive fluid devours every other metal with which it comes in contact.

Platinum is heavier than gold, and is met with generally in grains. On the coast of northern California a mixture of gold and platinum in tiny scales is obtained from the beach sand by washing. Occasionally platinum nuggets are found. One weighing twenty-two pounds was shown at the last Paris Exposition.

What do you think is the most expensive part of an ordinary incandescent electric lamp? The glass bulb? The brass fitting that sets into the socket? Neither. The platinum wire in every

little electric lamp costs more than any other portion of this modern remarkable light-giver.

By looking closely you will see that, running through the glass stem in the base of the lamp,

Steamer's Saloon Lighted by Electricity.

there are two bits of wire to which the carbon thread is attached.

Why do not the manufacturers use wire made of some other metal? Because platinum is the

only metal that expands and contracts at the same rate as glass.

The carbon thread would be burned up in a moment, if there was any air in the bulb when the electricity was turned on. Now, should the wire running through the glass stem expand more rapidly than the glass, the result would be the cracking of this fragile substance.

But, if the glass should expand faster than the metal, a space would be formed about the wire, and, however small this space might be, the air would find its way into the lamp, and the carbon thread would be instantly destroyed.

One ounce of platinum will furnish wire for eighty incandescent lamps. In the year 1891, as 10,000,000 such lamps were made, 125,000 ounces of platinum must have been used in wiring them. As this metal is worth $20 an ounce — a higher price than gold brings — a little work in multiplication will show us that the manufacturers of electric lamps spent for platinum wire, in that year, the large sum of $2,500,000.

Here, then, we have another proof of the encouraging fact that every new industry helps prior industries, and, of course, increases the number of hands employed in them. Furthermore, the new branch of labor, besides furnishing to perhaps thousands of persons the means of obtaining a

comfortable living, opens up new sources of wealth along its own line, and thereby adds to our national prosperity.

Lesson XXVIII.

For Future Needs.

"Kupfernickel!" We should have heard this long, foreign word more than once, if we had spent a day in a German silver-smelting furnace five hundred years ago. "Evil copper!" How strange an exclamation! What was meant by it?

Miners were very superstitious in the Middle Ages. Any ore that looked metallic, yet would not yield a useful metal, was considered to be the handiwork of gnomes — wicked, ugly dwarfs that haunted mines, and took delight in rendering man's industry fruitless. The absurd and silly belief in the existence of those malicious imps held firm possession of people's minds for several centuries.

Why were men in those old days so foolish as to believe that hobgobblins made poisonous ores in order that the fumes, released by smelting, might kill whoever breathed them? Because the good old times were times of gross ignorance.

Few even of the lords and ladies could read. Many a nobleman, many an owner of vast estates, had to use seal and wax to indicate his signature, because he did not know how to write his name. The poor man then was a serf bound to the soil — a slave that dared not leave the town in which he had been born. When a farm was sold, its laborers were sold with it. For hundreds of years a form of white slavery existed in England. No one need ever regret those "good old times."

The progress of metal working has freed the gnomes from blame. The German miner now eagerly seeks the kupfernickel ore that was once flung away as being deadly stuff. Its arsenical fumes are no longer regarded with terror; for science has invented exhaust-fans and safety-tubes to protect the smelters, while they extract, from the so-called "evil copper" of the Middle Ages, the beautiful and important substance that we term NICKEL.

In what parts of the globe is nickel found? In Norway, Germany, and the island of New Caledonia. Pennsylvania, Texas, North Carolina, and Nevada yield the metal. Rich deposits of its ore have been discovered in Oregon, and the most valuable nickel-mine in the world has recently been opened near Sudbury, Canada.

It was an American manufacturer that first

rendered nickel malleable by mixing manganese with it in the smelting process. The metal has the strength of wrought iron, but will not rust even in moist air. In several European countries, and in the United States, coins are made of nickel.

It is much used for coating cooking-vessels fashioned of copper or of iron, and in glass-making, and in decorating china. The art of nickel-plating had its origin in this country, and we produce more nickel-coated articles than all other nations combined. With copper and zinc, nickel forms German silver, a compound metal that, as we have already learned, is the basis of much of the silvered ware that we see for sale in stores.

In this age of experiment it is impossible to foretell the uses that science will find for a new substance. An American inventor mingled some nickel with molten steel, and rolled the compound metal into an armor plate.

The national government made, in the fall of 1891, an interesting test of the strength of this plate, compared with simple steel plates made — some in France, some in England, and some in the United States. Each plate was fastened on a heavy framework of timber, and was fired at with a big eight-inch rifled gun, placed only thirty yards away. The nickel-steel plate proved to be much stronger than any other one. Hence, all

our war-vessels built hereafter can be more thoroughly protected by using nickel-steel for armor sheathing.

This test revealed the value of an accident that perhaps would have otherwise remained unnoticed. One steel plate was found to be far stronger in the upper half than in the lower.

On inquiry, it was learned that when the lower half of the plate, red-hot, was plunged in oil, in order to anneal the metal, the oil caught fire. The workmen were compelled to flee from the flames. When the fire was extinguished, the piece of steel underwent annealing once more, with the result that the part doubly annealed resisted the cannon shot much better than the other portion. Here was another instance of accident advancing an industrial art.

Now have we read about all the metals? By no means! There are fifty-six metals known at present, and doubtless more are waiting to be discovered. Some of the rarer ones are very useful.

Tungsten, first brought to the world's notice, in 1783, by two Spanish chemists, was, until lately, merely an object of scientific curiosity. Now the metal is considered to be very important; for chemists have shown that when a little of it is melted with cast steel, the result is a kind of steel very hard, fine-grained, and tenacious.

Since guns of enormous caliber, like the one pictured on page 122, have come into vogue, it has become a matter of common knowledge that unfortunately such guns often burst under the tremendous strain caused by their heavy charges of powder. By adding a small per cent of tungsten to the steel of those big guns, they are rendered stronger and better able to withstand the sudden pressure created by the exploding powder. This new metal may, therefore, be credited with the saving of perhaps thousands of human lives.

Several preparations of tungsten are employed as pigments; and tungstate of soda has the highly valuable property of making clothing fire-proof. Thus is furnished a means of preventing the many dangerous accidents which occur from the burning of ladies' dresses.

Cobalt is obtained from an ore that was classed in earlier times with kupfernickel and other minerals supposed to have been made by evil spirits, in order to annoy the poor, hard-working miners. But nowadays we are anxious to get more cobalt ore. The potters and glass-makers owe to cobalt the beautiful blue color that we admire in their wares. This metal is very tenacious. A wire of it is twice as strong as an iron wire of the same size.

Albert the Great, a famous alchemist of the 13th century, is regarded as the discoverer of arsenic, a gray, lustrous metal which, on exposure to the air, turns black. The white oxide of the metal is the well-known arsenic of medicine, and is a virulent poison. It is, however, extensively used in tanning some of the finer furs exported from Russia. The metal itself enters into the composition of some brilliant green, red, and yellow pigments, and is combined with lead to form shot. Numbers of metallic ores contain arsenic, but this dangerous substance is procured chiefly from mines of arsenical pyrites (compounds of sulphur, iron, and arsenic). Germany and England furnish most of the cheap arsenic of commerce.

Chromium, or chrome, is a metal that supplies our artists with some beautiful paint-materials, producing orange and yellow colors. Its oxide imparts the finest green tints to porcelain. Chrome may one day become more important, as it is less fusible than even platinum, is extremely hard, and cannot be altered by air or water.

What sharp-eyed pupil has noticed the words "bismuth" and "antimony" on the labels of glass jars in drug stores? As the jars contained liquids, it is at first puzzling to learn that the words quoted are the names of metals. But iron is a metal, and you have seen some of the tinctures

of iron so commonly prescribed by doctors, have you not?

Bismuth melts at a very low heat, and therefore is often employed, in combination with lead and tin, as a solder for tinware. Britannia metal, pewter, and type-metal also contain bismuth.

In its native condition, no use has yet been found for antimony, but it forms valuable alloys. It is of great service in making metal for printers' types and for stereotype plates, from which newspapers are printed. Like bismuth, it is generally associated with the ores of other metals.

Thallium, a recent discovery in the mineral kingdom, already promises to be of considerable value. It gives to optical glasses density and power not obtainable without it, and this property alone makes thallium highly useful.

But the metal of the future is ALUMINIUM. It was discovered in the first quarter of this century by Sir H. Davy, an eminent English chemist. He found that a common clay is composed of earthy material and a metallic substance, which he named aluminium. The precious stones termed ruby, sapphire, garnet, and emerald, are oxides of this same clay. How strange it seems to learn that a bar of metal resembling zinc, and a gleaming gem, should be products of the same material, dull, soft earth!

Aluminium is, in appearance, white, with a marked bluish tint. The color can be improved, and the metal made more rigid by the addition of copper. A sheet of aluminium can be beaten out almost as thin as gold-leaf. It would seem easy to cast bells of the best quality from aluminium, as a suspended bar of the metal, when struck, emits a sonorous, musical note. But, singularly enough, an aluminium bell, made in the shape of an ordinary bell, has a tone very far from agreeable.

The first time that you examine a specimen of this new metal, you will be surprised at its lightness. Zinc is seven times heavier than water, gold nineteen times, but aluminium is only two and a half times heavier.

Aluminium, though stronger and more tenacious than steel, can, nevertheless, be turned in the lathe, or be chased and filed with ease.

An aluminium cup may be dropped from a height of ten feet, onto a stone pavement, without suffering injury. Being light and strong, the metal makes excellent tubes for telescopes and beams for balances. It is already in use for watch-cases, combs, pen-holders, and other small articles.

With copper, it forms an alloy that is as hard, tenacious, and malleable as iron, but is not liable to rust. This alloy is called aluminium-bronze, and is in growing demand for many purposes.

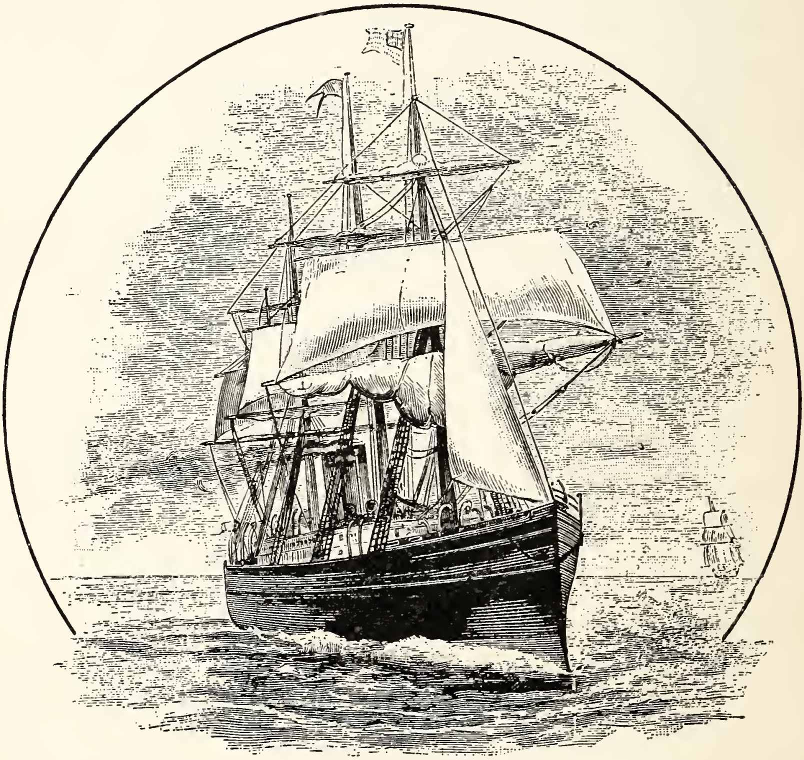
Its beautiful gold color makes it specially attractive for objects of art.

Cooking-vessels made of this strange clay-product are coming into favor: as, after heating, they cool very slowly. Fat or grease will not adhere to them, and they are not corroded by vinegar or fruit acids. Spoons and forks of aluminium are already in the market; but as this metal cannot be polished to rival silver in luster, the material of our table-ware, solid or plated, will probably not be changed very soon.

In the near future many new uses will doubtless be found for aluminium. The addition of a half-pound of it to a ton of molten steel renders an ingot of the latter metal perfectly sound when cast. This important discovery was made so late as 1891. In the same year an American mechanic succeeded in welding together aluminium and glass. It is believed that the process which he employed can be so improved as to render practicable the manufacture of that long-sought article, flexible glass. Think of bending a lamp chimney double without breaking it, or imagine yourself rolling a long window pane into a good stick!

But there is little doubt that aluminium will find its most extensive and important use in ship-building. In fact, the pioneer of aluminium ves-

sels has been already launched. At Zurich, Switzerland, there was constructed, in 1891, a steamboat, a tiny craft indeed, its engine being



Ocean Steamer.

of only two horse-power; but hull, machinery, and propeller were made from that wonderful metal of the future — a metal that in strength and lightness is far superior to the best steel. Her trial trip, made on the lake near the city, was a complete success.

When will this little Zurich pioneer have larger fellows on rivers and lakes in the United States? Perhaps soon. Nowadays, advances in the industrial arts are more quickly made than ever before in the world's history. There are still living hundreds of persons that saw the first iron steamer slide from the building dock into the water. Vessels of steel have been constructed within the last generation only.

We may, therefore, expect to see in a few years aluminium steamers of the largest size. Even before this century closes, we may take a trip across the Atlantic in some aluminium liner as big as the magnificent steamship pictured on the preceding page.

You may want to know why vessels are not now built of this remarkable white metal. Because it is too costly. At present we obtain it only by an expensive electrical process combined with furnace-work.

But the price of aluminium is falling. The earth *alumina* was formerly thought to be the sole source of the metal, but it is now prepared mostly from *cryolite*, a mineral that is found only in Greenland, but is obtained there in great abundance. Cheaper methods for extracting the metallic white treasure will be invented. Aluminium steamers, being much lighter than steel ones, can

carry larger cargoes, will not rust, will make much faster time — in short, offer so many advantages, that just as soon as the cost permits the construction of a great aluminium boat, the vessel will be quickly built.

Lesson XXIX.

From the Earth.

What should we understand by the phrase, "the raw materials of the earth"?

The ocean and the globe's crust furnish in a crude or raw state the means of food, clothing, and shelter. When natural products are turned by man's art into articles of use or luxury, we then have manufactured products.

The harvest of the teeming waters; the animals and plants on the earth's surface; the stone, the metals, the coal, the clays in the soil — all are raw materials. There is in the world a very large number of substances fit to serve us in health and sickness.

Each region of the globe has its special treasures. By commerce — that is, by exchange, — the people of any country may supply themselves with the products peculiar to other lands. If

Washington has plenty of timber, but no salt, while New York needs timber for building, but has salt to spare, each State may, by exchange, be supplied with the raw material that it lacks.

Without some acquaintance with the natural resources of a country, no people could live there. But, to live in comfort, the inhabitants of any region must know how to work up its raw materials into articles that will supply their wants. The required knowledge can be got only by the aid of experience.

We have already noted that one man works at one occupation and another man at another occupation, in order to make their united labor more productive. By this division of labor society goes into a general partnership or brotherhood, and every man's opportunities of making a good living are increased.

As workmen become more skilled when each one restricts himself to one branch of industry, they produce more for their employers, and receive higher wages. The money thus earned does not lie idle, but is spent in procuring the necessaries and comforts of life, thereby giving employment to other workers.

We do not, however, rest contented with collecting only such raw produce as wild nature yields. Farming and cattle-rearing give us a

greater abundance of food than we should have if we relied on chance alone.

It is often said that he who makes two blades of grass grow where only one grew before is a benefactor to his species. The truth of this statement is easily proved. Imagine the good which would result were the world's wheat-fields for this year to yield double their natural harvest!

The manifold uses of coal show the wonders which can be effected by science and art. That one raw material has completely changed all our great industries. By its means, Steam, the giant of modern Workland, has enabled us to score our immense territory with railroads, and to make our vessels independent of wind and tide.

These messengers of commerce help us, on both land and water, to exchange the products of one State or country for those of another. Steam has increased our nation's wealth till it is now almost beyond calculation.

This gas, evolved from water, drives the machines which turn our raw materials into manufactures of much greater value. But without coal how should we obtain the vast quantity of steam daily used?

Every year adds to our list of serviceable animal, vegetable, and mineral substances, while the increasing use of those raw materials already known calls

forth an increased yield of them. Our knowledge of nature's products and of the elements which compose them is due principally to chemistry, the most wonderful of modern sciences.

A nation's greatness depends largely on its possession of plentiful stores of raw materials. Every discovery of a new available substance, or of a new property of an old material, has suggested new uses; and fresh necessities have led to fresh researches.

In 1842 an English physician, while taking a walk in the outskirts of Singapore, noticed that the handle of a woodcutter's ax was made of some peculiar substance. He examined it carefully, learned where the material could be had, and soon sent a quantity of it to England.

Thus was introduced to commerce that important product *gutta-percha.* Without it we could not have laid our ocean telegraph cables, because no other known substance protects the electric wire so cheaply and so well. Gutta-percha is also used in making water-pails, speaking-trumpets, boats, and ornamental furniture; and bids fair to render us further valuable service.

Every useful discovery has been found to benefit the world in many ways that were not thought of at first. The record of man's progress from the Stone Age to this last decade of the 19th

century must give many a page to the history of new materials and to the skillful manner in which they have been utilized to further the well-being of mankind.

Lesson XXX.

Dreamers that Toiled.

In the Middle Ages many men, versed in the learning of their time, wasted their lives in striving after objects that existed in imagination only. The astrologers, deluded by the wild belief that the planets influenced for good or ill the fortunes of human beings, studied long and hard to learn the nature of each heavenly body's power. Hundreds of strong minds were wrecked on the rock of that strange delusion.

The alchemists buoyed themselves up with hopes based on a singular folly. All metals were held to be changeable into one another. It was supposed that each metal was a compound of sulphur and mercury in different proportions and in different degrees of purity.

For more than a thousand years after the fall of the Western Roman Empire (476 A.D.) the aim of most learned men was to find, by some

chemical process, the "philosopher's stone." This stone was considered to have the power of turning the baser metals into gold, of curing all diseases, and of keeping its possessor young forever.

But the change of cheap metals into gold could be made also by the magical force of a certain red powder; and there was a white liquid which could transform iron into silver. Unfortunately, however, neither powder nor liquid has ever yet been discovered!

The labors of the alchemists were not wholly fruitless. Those dreamers worked with remarkable skill, considering the little knowledge that they had. In the efforts which they made to reach their ideals, the extremely useful processes of refining metals, of distilling flower oils and herb juices, and of crystallizing liquids were all much improved.

The metal-worker's retorts and crucibles are relics of alchemy. If the searchers after the philosopher's stone never found the substance which was to give them boundless wealth and unfading youth, they brought to light, in the course of their experiments, many facts that advanced medical science.

About the middle of the 8th century, a foundation for the modern science of chemistry was laid by the discovery of strong acids and ex-

plosive mixtures. In the next two hundred years the Arabs produced some famous alchemists.

One of them, Djafar, gained considerable renown by discovering a mode of manufacturing nitric acid — an acid very valuable to-day in the industrial arts. He also first made that compound acid called aqua regia, a liquid that dissolves gold quite readily.

Another Arab, Rhazes, was the first to prepare sulphuric acid. This fluid is absolutely necessary to numerous modern industries. After Rhazes came the physician, Bechil, who obtained phosphorus, a mineral extensively used at the present time. Indeed, all the Arabian doctors of the Middle Ages were acquainted with the chemical science of their day.

But the alchemist who rendered mankind the most benefit was the Swiss physician, Paracelsus. He had nothing but contempt for mere seekers of gold and silver.

"True alchemy," he said, "is degraded by its false disciples, who employ it only in vainly trying to make the precious metals. This divine science has but one aim — to prepare tinctures and elixirs that shall restore lost health." Medicine owes much to the opium and calomel of this gifted man, as well as to the laudanum of his pupil, Quercetan.

Paracelsus and his followers were the first

doctors that compounded the drugs which they gave to their patients. Thus arose the demand for physicians having a knowledge of chemistry.

During the 16th and 17th centuries alchemists were to be found at the courts of kings, and men of all ranks studied the nature of minerals in the foolish hope of finding the mystic substances that could turn the more common metals into gold and silver ready for the mint.

In those days monarchs took a hopeful interest in the experiments of the alchemists, and often those early students had to suffer on account of the selfish greed of the kings. One of the English sovereigns, Edward III., issued to the Sheriff of Kent the following order, which, to people of this century, reads like a silly jest: —

"Wherefore, as Master William de Dalby, by the art of alchemy, knows how to make silver, you are hereby commanded to bring him up safely into Our Royal Presence, conducting him honorably, if he is willing to come; if not, *use force.*"

It is hard for us to form correct ideas of the difficulties which the alchemists had to overcome. There were no schools nor colleges in which they could study science.

Books on chemistry were unknown. A book on any subject cost a large sum of money, because printing had not been invented. Sheets of parch-

ment, written on by hand and rolled around a stick, made the volumes of the Middle Ages.

The few students of nature had no means of communicating with one another, except by visiting in person, and traveling was costly and dangerous. Each alchemist was obliged to think out the processes which he employed, and to make with his own hands the instruments and apparatus which he used.

By slow degrees alchemy merged into chemistry — that wonderful science which has done so much to improve our means of living.

The alchemists worked for a selfish ideal — the enriching of themselves by finding the philosopher's stone, or the powders that could turn every mineral into gold and silver. But the true ideals in science are to change the raw materials of the earth into forms useful to man, and to make life happier and nobler for us all.

We owe much to those clear-brained men who brought chemistry out the fog-land of alchemy. Especially should we remember, with the deepest gratitude, the names of Lavoisier, Dalton, and Liebig. Some day we may learn more about those distinguished scientists. Every industrial art of the present day is heavily indebted to them and to thousands of other gifted chemists who have most unselfishly labored to promote humanity's welfare.

Lesson XXXI.

Heroes of Industry.

No other metal possesses so many useful qualities as iron. No other metal is capable of so great a variety of applications. Almost every mineral contains some iron. Why, then, should this most valuable substance have been one of the last of the metals to come into general and constant use?

The answer to this question has been already given. Iron, though very widely diffused in nature, never presents itself in the form in which we commonly see it. To recognize its ore, and to separate the metal from the earthy materials mixed with it, demand the exercise of no small amount of thought and talent.

Persons having no knowledge of minerals would be unable to perceive any likeness between the reddish iron-stone from the mine, and the iron of a stove, for example.

Another reason why men were slow to avail themselves of iron, is found in the fact that this metal fuses only at a high heat. Zinc melts at 3° of a furnace thermometer; 130° is the fusing point of iron. Tin and lead melt at lower degrees

than zinc. To fuse iron ore, the intense heat of a blast-furnace is required.

We learned in an earlier lesson that Lord Dudley's invention of smelting iron with coke was not appreciated by the iron-workers of his time and country.

No doubt other improvements were needed to make Dudley's method a success. Until a more powerful blowing-machine had been devised, the reduction of iron ore by means of coal must have been limited for want of some mode of making the furnace fires hot enough.

As the demand for iron steadily increased with the increasing population, and as the timber supply for smelting purposes kept growing less every year, England was compelled to rely more and more on other countries for manufactured iron.

The number of English forges rapidly diminished. By the middle of the eighteenth century the total iron product of Great Britain amounted to only 18,000 tons annually.

But when the iron-masters could not obtain wood enough to smelt their ore, they were compelled to look around for some fuel to take the place of charcoal, the material which they had been accustomed to use for heating their furnaces.

It was soon found that coke made from coal answered their purpose almost as well as wood.

The coke was made by burning the coal in heaps in the open air.

Smiths began to use coal in their forge fires. To country blacksmiths the coal came in bags slung, two by two, on the backs of horses; for the roads in England then were so soft that no wagon could be drawn over them.

Finally a period was reached when coal came into general use, and necessity led to its regular employment in smelting ore of iron and in manufacturing the metal.

In the first quarter of the last century the chief cooking-utensils of English working-people were made of cast-iron. The art of casting had, however, made such small progress in England that almost all the cast-iron ware was imported from Holland and Germany.

An iron-worker named Abraham Darby resolved to enter on this lucrative branch of manufacture. He tried a number of experiments in kettle-making. His first molds were of clay; but they fell into pieces when the molten metal was poured into them. Trial after trial proved fruitless.

Then he determined to find out the true method of making the kettles; and, with this end in view, he sailed over to Holland, the country in which the best cast-iron articles were made. After persistent inquiry he ascertained that the molds for

iron-castings must be formed of fine, dry sand. That information was the secret which he had been so anxious to learn.

Returning to England, accompanied by some skilled Dutch workmen, Darby went into the business of casting hollow iron-ware, and met with great success.

The work was carried on at first with extraordinary secrecy, lest other iron-masters should copy the art. So carefully was the new manufacture guarded that, while casting was in progress, the workshop's keyholes were plugged with wood!

It was in Darby's works that coal was first used to smelt iron ore. The increasing demand for iron called for large supplies of the new mineral fuel. Pumping-machines, driven by steam, were employed to drain the water out of the coal pits, and inventors were encouraged to improve the steam-engine. One gain gave rise to another.

When coal-burning had been once started in England, it soon spread into various fields of industry. Many curious inventions served to augment the demand for coal.

In the year 1760 there lived near Sheffield a clock-maker named Huntsman. He was of immediate German descent, a very ingenious mechanic, thoughtful and observing. Having experienced great difficulty, year after year, in finding steel

clock-springs of good quality, he at last determined to try to make, for the purposes of his trade, steel of a better grade than could be procured then.

Many obstacles had to be surmounted before success crowned his long and patient labors. He had not only to find out the fuel most suitable, but also to build a furnace that would give a greater heat than any other furnace ever constructed.

Then he was obliged to make a crucible able to resist that heat; for he had finally come to the conclusion that, if he could only melt pieces of common blister-steel, and could pour the fluid metal into a mold, the ingot of steel, thus cast, would be of the same quality throughout.

After repeated failures he succeeded in producing steel harder and finer than had ever been sold before in England. So rapidly grew the demand for his ingots, that he had to set up a large steel-works for their production.

The hardware merchants showed much curiosity on the subject of this new branch of the metal manufacture. How did Huntsman make his ingots? What mysterious substances did he add to the ordinary steel?

For some years these questions remained unanswered. Huntsman kept his secret well, and piled up a fortune every year. His workmen were bound by the most terrible oaths never to tell the

processes that they employed: and, besides, as they received the highest wages paid in Europe for similar work, none of them wished to lose his situation.

All went well until one winter evening a stranger came to the gate of the works, and rang the bell. Snow was falling fast, and a bitterly cold wind swept across the moorland on which the manufactory was located.

When the gate was opened, the stranger, who appeared to be a farm hand, made a piteous appeal to be allowed shelter from the storm. The foreman, after scanning him closely, permitted him to enter. The poor fellow, seemingly worn out with cold and fatigue, stretched his weary limbs on the floor near the glowing furnace, and to all appearance was soon asleep.

The workmen began their casting operations. They cut bars of steel into bits, threw these into the crucibles, placed the crucibles in the furnace, and waited till the steel was melted.

Still the farm laborer did not stir. The men drew out the crucibles, poured their liquid contents into molds, and let the molten steel cool into small ingots.

Soon afterwards the stranger was observed to get up. He had been forgotten in the excitement of the casting operations; but, as he passed out of

the furnace-room, no one suspected that he had been merely pretending to sleep, and that not a step of their work had been taken unnoticed by his half-closed eyes.

Out he went, taking with him the secret of making cast-steel. In a few years there were hundreds of manufacturers of cast-steel in England.

Henry Cort did more than any other man to render practicable the manufacture of iron in vast quantities and at low cost. He showed the iron-masters how to use the puddling-furnace and the bar-rollers.

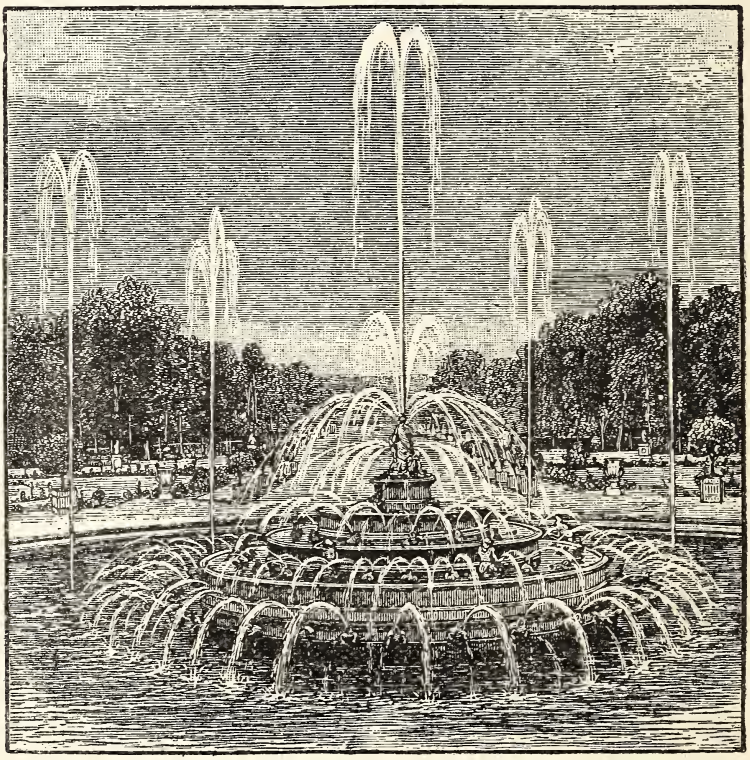
To him Great Britain owes, in no slight degree, that great abundance of cheap iron which has raised her to the first place among the metal-working nations of the world. He was the very Tubal Cain of his native land — the master-spirit of this iron age. His talents have added thousands of millions of dollars to England's wealth — and England let him die in beggary.

James Neilson, a Scotch engineer, should be accorded a high place among the heroes of industry, all of whom have deserved honors of their fellow-men. He was the inventor of the "hot blast" in iron smelting — a device bold, original, and useful in the highest degree.

Before he patented his process, the manufacturers of iron kept up the combustion of coal in

their furnaces by means of steady currents of very cold air.

Therefore, Neilson's proposal to employ hot air for the same purpose was at first received with



Fountain made of Iron.

contempt. What! a mere gas-engineer presume to instruct iron-workers how to make iron? And to say that *hot* air should be used! How impudent of this unknown Scotchman!

Years passed before Neilson was allowed the

full control of a blast-furnace in which he could give his plan a fair trial. The advantage of the new method was decisively shown with the very first charge smelted by its means.

Yet a generation had to come and go before the singular merit of the hot blast was acknowledged. Its use has saved millions of dollars a year, and has enabled the iron manufacturers to utilize ore that could not be, with advantage, smelted by any other method.

American genius has not been idle in the vast industry of iron-working. Forty years ago most of the work of a rolling-mill was done by the strong hands of workmen. To-day a thousand times more work is done by stronger hands of steel.

Powerful machines have superseded manual labor in many processes. Rotary furnaces, saving human beings from the exhausting toil known as puddling the iron, are being rapidly introduced into all large iron-works.

Better methods are employed. Skill has displaced ignorance. Science has proved to be a surer and more profitable guide than guess-work. "Old things are passing away, and all things are become new."

Let us not forget, however, how deeply we all, old and young, are indebted to the eminent workers of the past.

We inherit the benefits of the industry and skill of former ages. Almost all the comforts and luxuries of life are the results of human effort put forth in bygone times. Only by slow and painful steps have nature's secrets been mastered, and the earth's raw materials been made serviceable to our daily needs.

No human labor, rightly directed, has ever been totally wasted. Even attempts resulting in failure have not been really useless, but have helped in some way to lift our race to a higher plane in skill or knowledge.

In the long history of man's struggle with the forces of the world about him, there is no record that an advantage once gained has ever been lost. Every step in advance has given mankind a firmer foothold for doing more noble and useful work.

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